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JOURNAL of PALEONTOLOGY

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CEPHALOPODS FROM THE UPPER CRETACEOUS OF KANSAS

A. L. MORROW
Wichita, Kansas

ABSTRACT

Several undescribed species of ammonites have been recognized during the course of a general faunal study of the Coloradoan invertebrates in Kansas. Ten are herein named and the remainder, because of inadequate material, are merely noted. Species of *Pseudaspidoceras*, *Mammites*, *Tragodesmoceras*, and *Borissjakoceras* have not been reported previously from Kansas. The addition of these species to those already known should make possible a finer zoning and more detailed correlation of the strata of the Colorado group.

This paper, which is part of a general faunal study of the Coloradoan invertebrates, to be presented as part of the dissertation requirement for the degree of Doctor of Philosophy in the Department of Geology at Yale University, includes only undescribed ammonoids and a single nautiloid. The Colorado group as here used comprises the strata between the Dakota sandstone and the Pierre shale. In ascending order the formations are: Graneros, Greenhorn, Carlile, and Niobrara.

Of the larger fossils preserved in strata of the Colorado group, the mollusks almost completely dominate. Of these the pelecypods far outrank the other orders in individual numbers and to a lesser degree in species. The cephalopods are quite common locally but are generally poorly preserved, except where found in concretions. Such an occurrence usually displays the original shell material with its nacreous luster. Except in these concretionary zones the abundance of ammonite species in these formations is not evident on cursory examination. Several field seasons of collecting yielded an ammonite fauna totaling thirty species, of which fourteen are described here. The fauna is listed in the accompanying table which shows the known stratigraphic range of each species. The types of species described in this paper will be deposited in the Geology Museum at the University of Kansas.

I take this opportunity to extend sincere thanks to those who have given valuable aid in the field and laboratory: Prof. Carl O. Dunbar of Yale University, Drs. R. C. Moore and K. K. Landes of the Kansas Geological Survey, and Dr. J. B. Reeside of the U. S. Geological Survey.

DESCRIPTION OF SPECIES

Genus BORISSJAKOCERAS Arkhanguelsky

BORISSJAKOCERAS REESIDEI Morrow, n. sp.

Plate 49, figures 7*a*, *b*; Plate 50, figure 5; Text figure 8

Shell very small, flattened-discoidal; flanks flat, nearly parallel; venter narrowly rounded at a shell diameter of 1 cm., becoming more broadly rounded with continued growth but never developing a well-defined ventro-lateral shoulder; whorls deeply embracing, the preceding whorl being five-sixths covered at a diameter of 2 cm.; umbilicus at this

Genera and species	Graneros	Greenhorn				Carlile		Niobrara	
		Lincoln	Hartland	Jetmore	Pfeifer	Fairport	Blue Hill	Hays	Smoky Hill
Eutrephoceras sp.	—	—	—	—	—	—	—	×	—
Borissjakoceras reesidei Morrow, n. sp.	×	—	—	—	—	—	—	—	—
Borissjakoceras aplatum Morrow, n. sp.	—	—	—	—	—	—	×	—	—
Baculites calamus Morrow, n. sp.	—	—	—	—	×	—	—	—	—
Baculites sp.	—	—	—	—	—	—	—	—	×
Tragodesmoceras bassi Morrow, n. sp.	—	—	—	×	×	—	—	—	—
Acanthoceras? amphibolum Morrow, n. sp.	×	—	—	—	—	—	—	—	—
Pseudaspidoceras cornucostale Morrow, n. sp.	—	—	—	×	—	—	—	—	—
Mammites wingi Morrow, n. sp.	—	—	—	×	×	—	—	—	—
Mammites rectangulus Morrow, n. sp.	—	—	—	×	—	—	—	—	—
Mammites sp.	—	—	—	×	—	—	—	—	—
Scaphites pygmaeus Morrow, n. sp.	—	—	—	—	—	—	×	—	—
Scaphites carlilensis Morrow, n. sp.	—	—	—	—	—	—	×	—	—
Ammonite sp.	—	—	—	—	—	—	—	—	×

diameter 0.31 cm.; umbilical shoulder abruptly rounded, umbilical slope steep, nearly parallel to the axis of coiling; very small obscure nodes may be present at the ventro-lateral margin in stages up to 1 cm. diameter; surface ornamented by faint sigmoidally curved growth lines which bend sharply forward as they cross the venter, recording a pronounced ventral rostrum, and with one flexure on the flank marking one lateral crest; suture very simple, the lobes being narrow and the saddles broad. First lateral saddle bifid, second and third trifid, fourth entire; lateral lobe bifid, remainder entire.

Diameter of figured specimen 2 cm.; thickness 0.6 cm.; height of last whorl 1 cm.

This species is represented by three individuals in the collection, all from the locality given below. The suture figured was taken from a specimen slightly smaller than the holotype, at a whorl height of 0.6 cm. Figure 1*a–c*, Plate 50, is a drawing of Arkhanguelsky's original

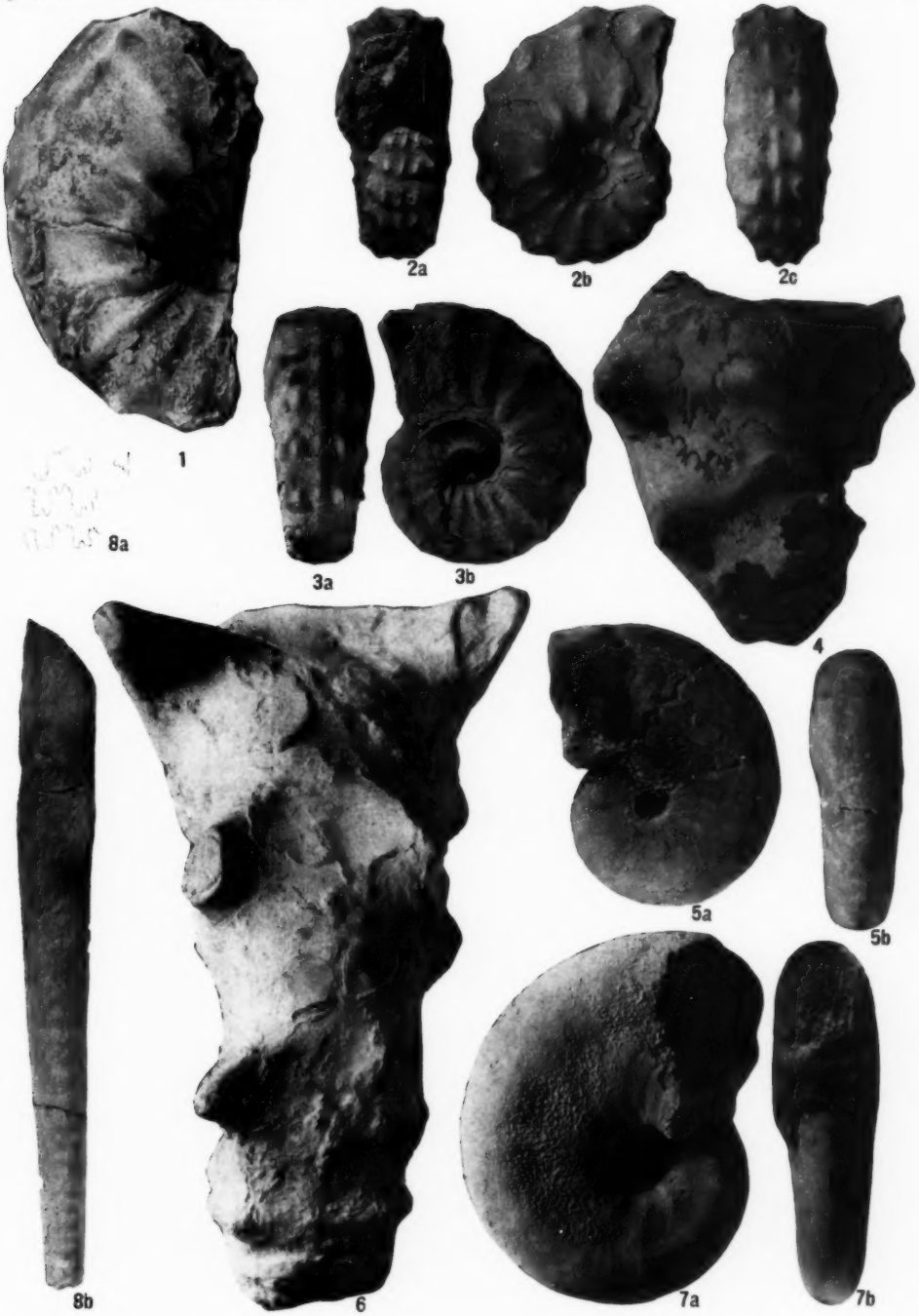
EXPLANATION OF PLATE 49

FIGS. 1–4, 6—*Acanthoceras? amphibolum* Morrow, n. sp. 1, Side view of specimen of moderate size, ×⅔. 2*a–c*, Front, side, and back views of a small individual showing the earlier ornamentation, ×1⅓. 3*a*, *b*, Back and side views of a shell of intermediate development between 1 and 2, ×⅔. 4, Side view of a portion of two whorls, the inner whorl at a similar stage to that of figure 3, and the outer whorl slightly less developed than figure 6. For the whorl section of this specimen see text figure 4. ×⅔. 6, Back view of a large specimen showing extreme development of nodes on the living chamber. Plaster cast of a specimen in the U. S. Nat. Mus. collections. ×⅔. Figs. 1–4 show specimens from the upper Graneros shale on the south bank of Smoky Hill River, south of Wilson, Kansas. (p. 470)

5*a*, *b*—*Borissjakoceras aplatum* Morrow, n. sp. Side and back views of the holotype, ×6⅔. (p. 465)

7*a*, *b*—*Borissjakoceras reesidei* Morrow, n. sp. Side and front views of the holotype, ×2⅔. (p. 463)

8*a*, *b*—*Baculites calamus* Morrow, n. sp. Side view and suture of the holotype; *a*, ×1⅓; *b*, ×⅔. (p. 473)



Morrow, Cretaceous Cephalopods

figures of the genotype, *B. mirable*, by Miss Wieser of the U. S. Geological Survey.

Remarks.—This interesting genus was described by Arkhanguelsky (1)[1] from lower Turonian rocks of Turkestan. The genotype, *B. mirable*, was the only one described and to the writer's knowledge the genus has not been reported elsewhere. Doctor Reeside, who called the writer's attention to this genus in 1930, has found several specimens in the U. S. Geological Survey collections from widely separated areas. Although similar in general, they differ specifically from the species here described. To my knowledge, no American species of the genus have been found outside of rocks of Turonian age, and as the group is easily recognized and compact it may prove valuable in regional or international correlation.

Borissjakoceras mirable Arkhanguelsky differs from *B. reesidei* mainly in being more loosely coiled so that at a diameter of 2.2 cm. the umbilicus is 0.65 cm., or twice as wide as in our species at equal shell diameters. The suture of the two species is surprisingly alike, having the same number of elements and digitations with similar dimensions, differing only in minor detail. Though Arkhanguelsky describes the shell as being perfectly smooth, his figure shows distinct, curved ventro-lateral ridges which probably correspond to the outer part of a crowded area of growth lines, as shown in the figures of *B. reesidei*.

Type.—Holotype from the upper Graneros shale south of Wilson, Ellsworth County, Kansas.

BORISSJAKOCERAS APLATUM Morrow, n. sp.

Plate 49, figures 5*a*, *b*; Plate 50, figure 6; Text figure 7

Shell very small, flattened discoidal, with flanks flat and nearly parallel; venter broadly rounded in all stages; whorls increasing proportionally in height with growth. At a diameter of less than 0.5 cm. the venter joins the flanks in a faint ventro-lateral shoulder which increases slightly in prominence with growth, whorls deeply embracing; umbilicus small with steep slopes; surface without nodes. Suture very simple; first lateral saddle entire, second trifid, third bifid, remainder entire; first lateral lobe rather deeply bifid, about as broad as ventral lobe, second lateral lobe bifid, narrow, remainder entire.

Diameter of the holotype, 7 mm.; thickness, 2.2 mm.

Only one complete specimen and two impressions of the venter have been found. The very small size of these specimens suggests that they may be juvenile. However, the suture appears to be as mature as that of the larger species, *B. reesidei*. The septal development can be studied back to very young stages in which the elements are all entire and simply curved.

Remarks.—*B. aplatum* differs from *B. reesidei* mainly in the detail of its suture and in size. The latter has a bilobed first lateral saddle contrasted to the entire saddle of the former. The first lateral lobe is broader, shorter and more deeply divided in *B. aplatum* and the second lateral lobe is bifid instead of entire. The development of the whorl section also differs in these two species. *B. aplatum* shows an early development of a ventro-lateral shoulder, whereas in *B. reesidei* there is no suggestion of such a feature until a much later stage.

Type.—The holotype is from a calcareous concretion zone in the upper Blue Hill shale member of the Carlile formation, south of Tipton, Mitchell County, Kansas, SE. $\frac{1}{4}$ sec. 4, T. 9 S., R. 10 W. The occurrence of this species in the upper Carlile extends the known range of the genus considerably.

Genus SCAPHITES Parkinson

SCAPHITES PYGMAEUS Morrow, n. sp.

Plate 50, figures 2*a–e*, 3

Shell small; whorl section in septate portion nearly circular except for im-

[1] Numbers refer to bibliography at end of paper.

pressed zone; younger whorls deeply embracing; umbilicus very small. The gerontic living chamber begins when shell has reached a diameter of about 2 cm. recurving rather abruptly, expanding slightly and becoming depressed a little in front of the last septum, and becoming somewhat constricted again near the aperture; ventral periphery of the aperture simple, dorsal side with a lappet; shell in very young stage smooth and globular. At a diameter of about 4 mm. straight, low, rounded ribs appear, crossing the venter and dying out toward the umbilicus, increasing in prominence with growth and becoming sharp crested. Their spacing increases rather abruptly on the living chamber, again becoming more closely spaced near the aperture. Ribs are of two kinds; primaries, which cross the venter and continue to the umbilicus, and secondaries, which begin to be intercalated between them about midway through the last septate volution. As a rule two of these are added for each primary rib. One coalesces with the primary on the side, and forms by this junction a raised, radially elongate, lateral elevation, being more pronounced on the gerontic living chamber. The other is simply intercalated, crossing the venter and dying out on the flanks; or in some cases these secondary ribs are free on one side of the shell and joined on the other. There are from 48 to 52 ribs crossing the exposed venter of the adult shell, divided about equally between the septate portion and the living chamber. The suture is rather simple with the elements not deeply divided. The details are shown by figure 2*a*, Plate 50, which is the suture of the penultimate septum.

Greatest diameter of holotype, 4 cm., greatest thickness across the living chamber, 2.1 cm.

Remarks.—*Scaphites pygmaeus* and *S. carlilensis* are very much alike in many details, the principal difference being in the size. The former is consistently smaller, all specimens being very nearly the size of the figured specimens. Another constant difference is in the number of ribs crossing the venter, *S. carlilensis* having from six to ten more.

Both species are apparently restricted to the Carlile, having been found only in the concretionary zones of the upper Blue Hill shale member.

Type.—The holotype is from near the top of the Blue Hill shale, SE. ¼ sec. 4, T. 9 S., R. 10 W., Mitchell County, Kansas.

SCAPHITES CARLILENSIS Morrow, n. .sp

Plate 50, figure 4*a–d*

Shell of medium size for the genus; whorl section nearly circular in all stages available; umbilicus very small; gerontic living chamber beginning at a diameter of about 3.3 cm. and describing a semicircular curve as seen in side view; shell expanding a little in front of the last septum and slightly contracting at the aperture, the margin of which is simple on the ventral side and has a short, broadly rounded dorsal lappet; whorls at a diameter of about 5 mm. ornamented by straight, low ribs which cross the venter and die out at the umbilicus,

EXPLANATION OF PLATE 50

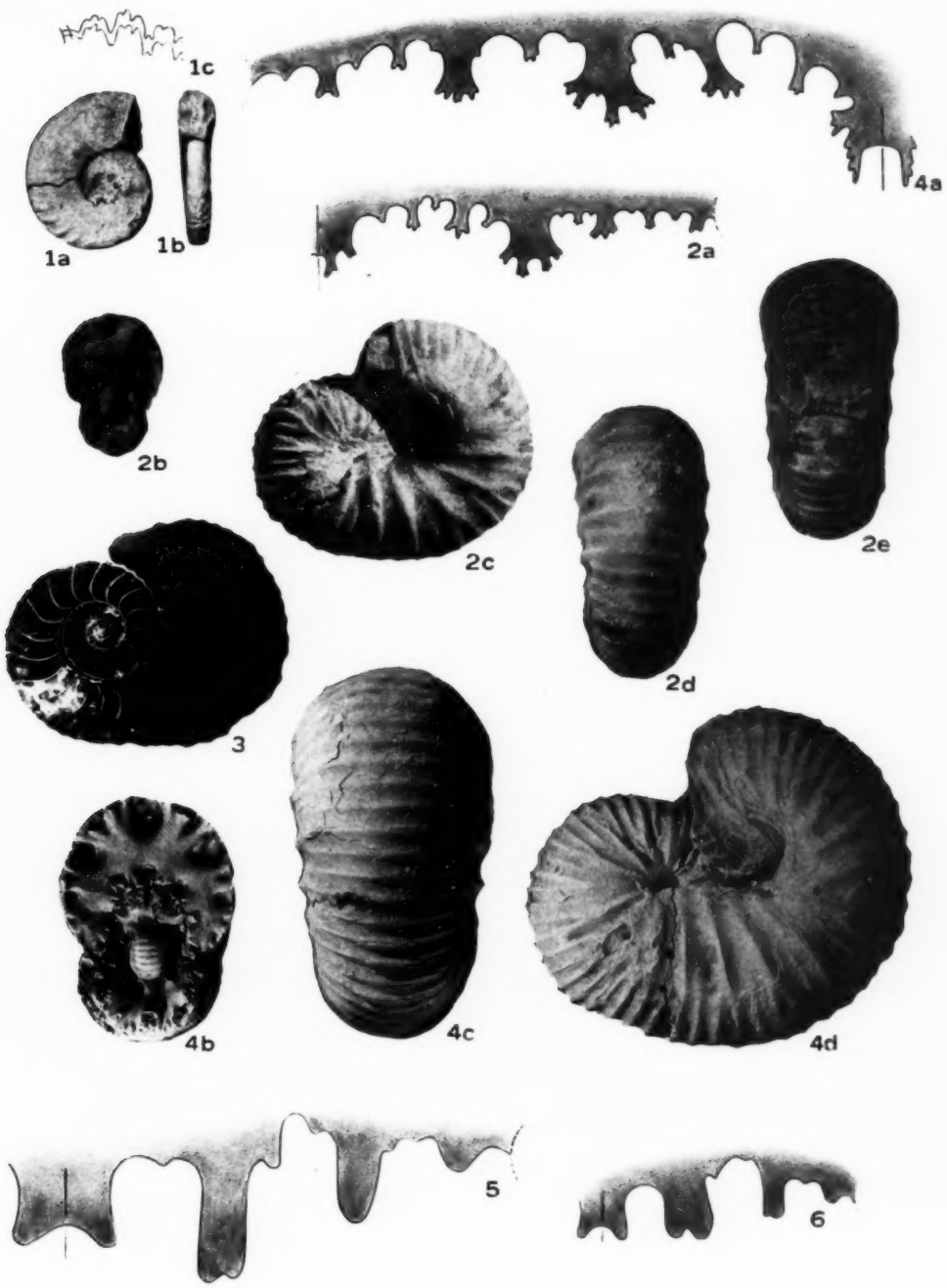
FIGS. 1*a–c*—*Borissjakoceras mirable* Arkhanguelsky. *a*, *b*, Side and front views of the genotype ×1. *c*, Suture, approximately ×2. Drawings by Miss Wieser, after Arkhanguelsky. (p. 465)

2*a–e*, 3—*Scaphites pygmaeus* Morrow, n. sp. 2*a*, Suture, ×2½. 2*b*, Broken to show whorl sections, ×1. 2*c–e*, Side, rear, and front views, ×1. 3, Side view of a specimen sawed through the medial plane, ×1. (p. 465)

4*a–d*—*Scaphites carlilensis* Morrow, n. sp. *a*, Suture, ×2½. *b*, Front view with living chamber broken away, ×1. *c*, *d*, Back and side views, ×1. (p. 466)

5—*Borissjakoceras reesidei* Morrow, n. sp. Suture, ×10. From a specimen with whorl height of 0.6 cm. (p. 463)

6—*Borissjakoceras aplatum* Morrow, n. sp. Suture taken from the holotype, at whorl height of 0.3 mm., ×10. (p. 465)



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rapidly increasing in prominence with growth and becoming sharp crested. Fifty-eight ventral ribs are exposed on the adult, with about 27 of these being confined to the living chamber. The nature and development of this ribbing is the same as described for the preceding species, *Scaphites pygmaeus*, and the suture is also essentially the same.

Greatest diameter of holotype, 5.5 cm.; greatest thickness across the living chamber, 2.7 cm.

Remarks.—This species shows some similarity to the Niobrara species, *S. vermiformis* Meek, and especially *S. vermiformis* var. *binneyi* Reeside in size and suture, though they differ considerably in their surface sculpture. The nature of the ribbing is somewhat like that of *S. larvaeformis* Meek, but the latter is much smaller and the extended body chamber is relatively longer and continues nearly straight for some distance past the last septum.

Type.—The holotype is from the SE. ¼ sec. 4, T. 9 S., R. 10 W., Mitchell County, Kansas. Locally this species is very common in the concretionary zones of the upper Carlile shale in Kansas.

Genus MAMMITES Laube and Bruder

MAMMITES WINGI Morrow, n. sp.

Plate 51, figure 2; Plate 52, figure 2*a–c*; Text figure 2

Shell large; whorls stout, subquadrate in section with height greater than breadth, the whorl section exclusive of nodes becomes more nearly circular with increasing age. A shell having a diameter of 17 cm. embraces the preceding whorl by about one-fourth the height of the final whorl; at the same diameter the width of the umbilicus is equal to about two-thirds the height of the final whorl; at 30 cm. they are about equal. A series of low, prominent, radially elongate nodes arise on the umbilical shoulder, merging into broad, low lateral ribs which terminate in a double row of ventral nodes, the lower and more prominent row producing a subdued ventro-lateral shoulder in the last stages of shell growth, the inner row becoming obscure and finally disappearing while the outer row becomes very prominent. With the reduction of the inner nodes there is a tendency for the succeeding nodes and ribs to be more irregularly spaced, with an occasional ventro-lateral node bearing neither a lateral rib nor a corresponding umbilical node, so that a shell at a diameter of 17 cm. bears fourteen ventral sets of nodes and ten umbilical nodes. The venter in the adult is broad and gently convex, bearing neither keel nor median nodes. The living chamber occupies about one-half of the final whorl. Septa moderately approximated; siphonal lobe nearly twice as long as wide, terminal branches nearly parallel; first lateral sinus about equaling the siphonal lobe in length and breadth, being merely divided into short branchlets; first lateral lobe longer and much broader than any of the other elements, divided into two unequal branches, the dorsal branch being larger and more deeply divided; second lateral sinus tripartite, auxiliaries little divided; second lateral lobe serrated and irregularly divided; third lateral sinus tripartite, broader than second lateral sinus but more divided; remaining elements quite simple.

Diameter of holotype 17 cm.; width of umbilicus 5.5 cm.; height of whorl, 7 cm.; thickness of whorl 7 cm.; diameter of largest specimen collected, 33 cm.

Remarks.—The characters of this genus are discussed by Laube and Bruder (2) and Pervinquiére (4). There seems to be little doubt that this and the following species belong to *Mammites* in its strict sense. A few American species of this type have been erroneously identified as *Acanthoceras*, but an important generic character of the latter is the presence of a median ventral row of tubercles. The Kansas specimens show no evidence of this feature at any stage of growth. Though there is very little reference to this genus in the North American literature, it is the most prom-

inent feature of the Kansas Greenhorn ammonite fauna, and is restricted to this formation. *Mammites wingi* is the most abundant of the species of *Mammites* in the collection.

Type.—Holotype from sec. 16, T. 6 S., R. 3 W., Cloud County, Kansas. One specimen is from the Pfeifer member and the others, including the holotype, are from the Jetmore. The holotype was collected by Dr. Monta E. Wing, in whose honor the species is named.

MAMMITES RECTANGULUS Morrow, n. sp.

Plate 53, figure 6; Text figure 6

Shell large; whorl section quadrate, flanks straight, nearly parallel, venter broad, slightly convex, height of whorl increasing rapidly with growth. At a shell diameter of about 25 cm. the whorl is 10 cm. high and 7 cm. wide, one-half whorl earlier, or at a diameter of 14.5 cm. the whorl is 7 cm. high and 4.2 cm. wide; whorls moderately embracing, covering about one-third of the preceding whorl; umbilicus moderately broad, 6.5 cm. at a diameter of 25 cm.; surface of the adult shell ornamented by low, broad umbilical nodes, becoming more elongate and rib-like in earlier stages, and a corresponding row of more prominent ventro-lateral nodes; details of the suture not determined.

Remarks.—The holotype is rather poorly preserved but shows sufficient characters to distinguish it. It differs markedly from *Mammites wingi* in the greater rate of increase of the whorl height. The umbilicus is much broader in the latter, being one-third larger at a shell diameter of 25 cm. Another difference is in the stouter whorl of *M. wingi*, especially in the adult. The diagram showing the whorl sections is in part a reconstruction, as is apparent from the photograph of the specimen, but it is believed to represent with fair accuracy the section of the undistorted shell. There is a suggestion of a double row of ventral nodes at a shell diameter of 15 cm. The venter is not available in earlier stages, but it is probably similar to *M. wingi*.

Type.—Holotype from the lower Jetmore member of the Greenhorn formation, SE. ¼ sec. 34, T. 4 S., R. 3 W., Republic County, Kansas.

MAMMITES sp.

A fragment showing parts of two volutions, though not complete enough for specific description, is worthy of mention. At a whorl height of 5 cm. and width of 4 cm. the fragment shows very prominent, conical dorso-lateral nodes. The outer set of the double row of ventro-lateral nodes is also conical and only slightly less prominent. There are two pairs of ventral nodes for each dorso-lateral node.

This fragment is quite different from the other species of this genus, especially in its very prominent conical nodes which are not on the umbilical shoulder but ventral to it on the flank. There are no ribs on the flanks, a fact which further distinguishes this fragment from comparable stages of related species.

From the lower Jetmore member, Greenhorn formation, SE. ¼ sec. 34, T. 4 S., R. 3 W., Republic County, Kansas.

Genus TRAGODESMOCERAS Spath

TRAGODESMOCERAS BASSI Morrow, n. sp.

Plate 52, figures 1*a–c;* Plate 53, figures 3–5; Text figures 1, 3

Shell large, compressed-discoidal; shells as much as 7 to 8 cm. in diameter

EXPLANATION OF PLATE 51

FIGS. 1*a–c*—*Pseudaspidoceras cornucostale* Morrow, n. sp. Back and side views, and suture of holotype, ×½. (p. 469)

2—*Mammites wingi* Morrow, n. sp. Side view of a specimen from the Pfeifer, ×½. (p. 467)

3, 4—*Acanthoceras? amphibolum* Morrow, n. sp. 3, Suture from the specimen shown on Plate 49, figure 4, ×½. 4, Suture from Plate 49, figure 2, ×3. (p. 470)

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having a heart-shaped whorl section, the keel being quite acute, but from this size up to a diameter of about 20 cm. the venter is more or less rounded, while with continued growth past this stage the venter becomes more narrowly rounded and finally sharply acute; whorls rather deeply embracing; young shell ornamented by prominent sigmoidally curved ribs, rising at the umbilicus, crossing the flank, and meeting the venter obliquely so that, seen in edge view, the line of the venter bisects a V-shaped ridge whose sides diverge away from the aperture. This ribbing becomes less prominent with growth, a whorl at a height of 8 cm. still showing it faintly. The suture figured is from the holotype at a whorl height of 6 cm. It is quite complex and highly digitated. The first lateral lobe is very much larger than any other of the elements and is tripartite with numerous secondary branches. The entire suture is minutely serrated.

Diameter of holotype about 25 cm.; height of final whorl 10.5 cm.; thickness 6 cm.

Remarks.—Two large incomplete specimens from Kansas and one from the Greenhorn of Colorado, and several fragments of much smaller individuals represent this species in the collection. These small individuals are believed to be young stages, though they might possibly prove to be a much smaller distinct species. The whorl section of the Colorado specimen is interesting in showing both whorls similar in outline, that is, the venter of the outer whorl has passed the rounded stage and the inner whorl has not yet reached that point. The whorl section of the holotype is from a slightly larger shell and shows the venter of the inner whorl rounded.

The Lower Cretaceous genera, *Desmoceras* and *Puzosia*, have been used rather broadly to include this group of Upper Cretaceous ammonites. Spath (5) proposed the genus *Tragodesmoceras* to include several Upper Cretaceous species which had previously been referred to the genera mentioned above. He designates *Desmoceras clypealoides* Leonhard as the genotype and also includes *T. mulleri* (Grossouvre), *T. hernense* (Schlüter) and *T. clypeale* (Schlüter). He characterizes the genus by the statement that it "specializes in crenulation of the venter." Figures of the genotype, *T. clypealoides* (3), show it to have more closely spaced ribs at corresponding stages than in *T. bassi*, and this ornamentation continues to be prominent at a later stage.

Type.—Holotype collected by W. W. Rubey and N. W. Bass, from the Jetmore member of the Greenhorn formation, Lincoln County, Kansas.

Genus PSEUDASPIDOCERAS Hyatt

PSEUDASPIDOCERAS CORNUCOSTALE Morrow, n. sp.

Plate 51, figures 1*a–c;* Text figure 5

Shell moderately large, compressed discoidal, with whorl section subquadrate; umbilicus wider than the height of the final whorl; shell embraced by about one-sixth the height of the succeeding whorl. Prominent nodes on the umbilical shoulder give rise to rather strong, straight lateral ribs, which in early stages are terminated at the ventro-lateral margin by a pair of nodes. In stages up to 12 cm. in diameter these are reduced to a single strong node. In later shell growth the ribs pass completely over the venter, curving forward as they do so. The nodes at the ventro-lateral margin become expanded into long, bluntly pointed spines with their base considerably elongated parallel to the ribs. Often the lateral ribs bear ventral nodes or spines, but lack the umbilical node, thus producing ten umbilical and seventeen ventral nodes on the last whorl of the holotype. The spines are most prominent on the living chamber which occupies a little more than one-half the final whorl. Both ribs and spines become more irregularly spaced toward the aperture. The adult suture displays a rather simple ventral lobe, longer than wide; the first

TEXT FIGS. 1, 3—*Tragodesmoceras bassi* Morrow, n. sp. Cross sections, ×½. 1, Specimen from Colorado; 3, holotype. (p. 468)
2—*Mammites wingi* Morrow, n. sp. Cross section of holotype at diameter of 17 cm., ×½. (p. 467)
4—*Acanthoceras? amphibolum* Morrow, n. sp. Cross section showing change in general outline and arrangement of nodes, ×½ (Pl. 49, fig. 4). (p. 470)
5—*Pseudaspidoceras cornucostale* Morrow, n. sp. Cross section from living chamber of the holotype, ×½. (p. 469)
6—*Mammites rectangulus* Morrow, n. sp. Cross section of holotype at diameter of 23 cm., ×½. (p. 468)
7—*Borissjakoceras aplatum* Morrow, n. sp. Cross section of holotype, at diameter of 6 mm., ×10. (p. 465)
8—*Borissjakoceras reesidei* Morrow, n. sp. Cross section of holotype at diameter of 2 cm., ×3½. (p. 463)
Portions of sections shown by broken or dotted lines are diagrammatic.

lateral saddle is moderately asymmetrical and trifid with the auxiliaries rather simple; first lateral lobe asymmetrical, weakly trifid, nearly as high as the ventral lobe, much wider than any of the other elements; second lateral saddle similar to first; second lateral lobe narrow, not as deeply divided or so long as preceding lobes; remaining elements short and rather simple.

Diameter of holotype 17 cm.; height of final whorl 6 cm., breadth 5.5 cm.; width of umbilicus 8 cm.

Remarks.—The species is readily distinguished by the closely spaced and very prominent ventro-lateral spines on the adult shell. The holotype is the only representative of this species in our collection, but its characters are so striking that no hesitation is felt in giving it a name.

Pervinquiére (4) gives an excellent discussion of the groups *Mammites* and *Pseudaspidoceras*, though he considers the latter as a subgenus of *Mammites*. *Pseudaspidoceras* is distinguished by its broader umbilicus and more compressed shell with a markedly quadrate whorl section. These genera are probably closely related, both showing in their early whorls a double row of ventro-lateral nodes. In *Pseudaspidoceras* they are replaced by a single row at a much smaller shell diameter than in *Mammites*. Both genera lack median nodes on the venter at all growth stages, though Pervinquiére states that some forms may possess a low median keel. He intimates that the presence of the keel may be caused by a slight projection of the siphon.

Type.—Holotype from the Jetmore member of the Greenhorn formation, center of west side sec. 26, T. 3 S., R. 3 W., Republic County, Kansas.

Genus ACANTHOCERAS Neumayr

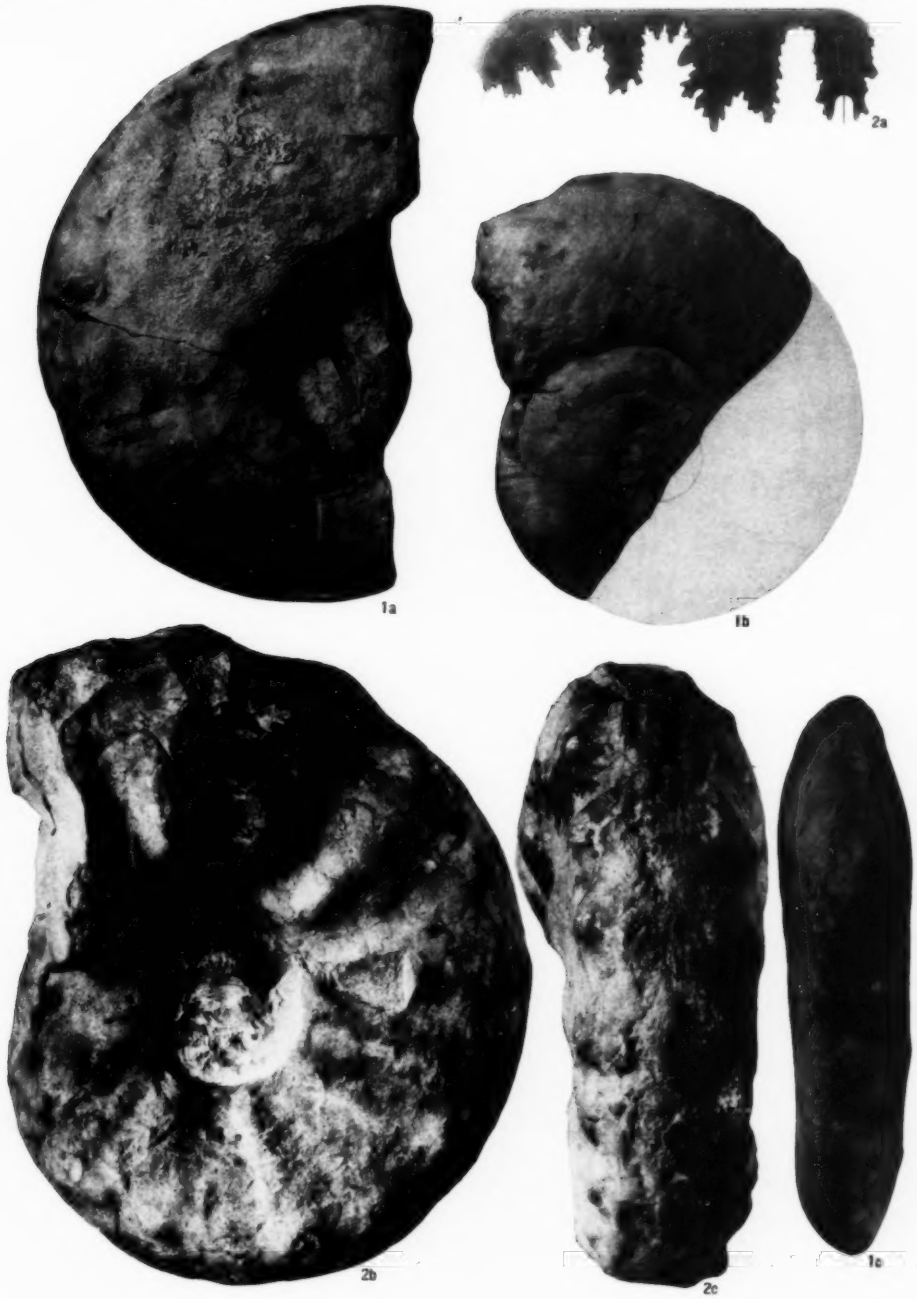
ACANTHOCERAS? AMPHIBOLUM Morrow, n. sp.

Plate 49, figures 1–4, 6; Plate 51, figures 3, 4; Text figure 4

Shell medium sized, whorls slightly embracing; earliest whorl section broadly rounded ventrally, much wider than high. At a shell diameter of 2 mm. the whorl is 0.6 mm. high from dorsum to venter, and 1.6 mm. in breadth, the venter being broadly rounded and smooth, and the whorl section distinctly rectangular though still considerably wider than high at this size. At a diameter of about 1.5 cm. the shell has assumed the

EXPLANATION OF PLATE 52

FIGS. 1*a–c*—*Tragodesmoceras bassi* Morrow, n. sp. *a*, Side view with the outer whorl removed, ×½. *b*, Side view of the holotype to show the general form, ×½. *c*, Back view of *a*, ×½. (p. 468)
2*a–c*—*Mammites wingi* Morrow, n. sp. Suture, side and back views of holotype, ×½. (p. 467)



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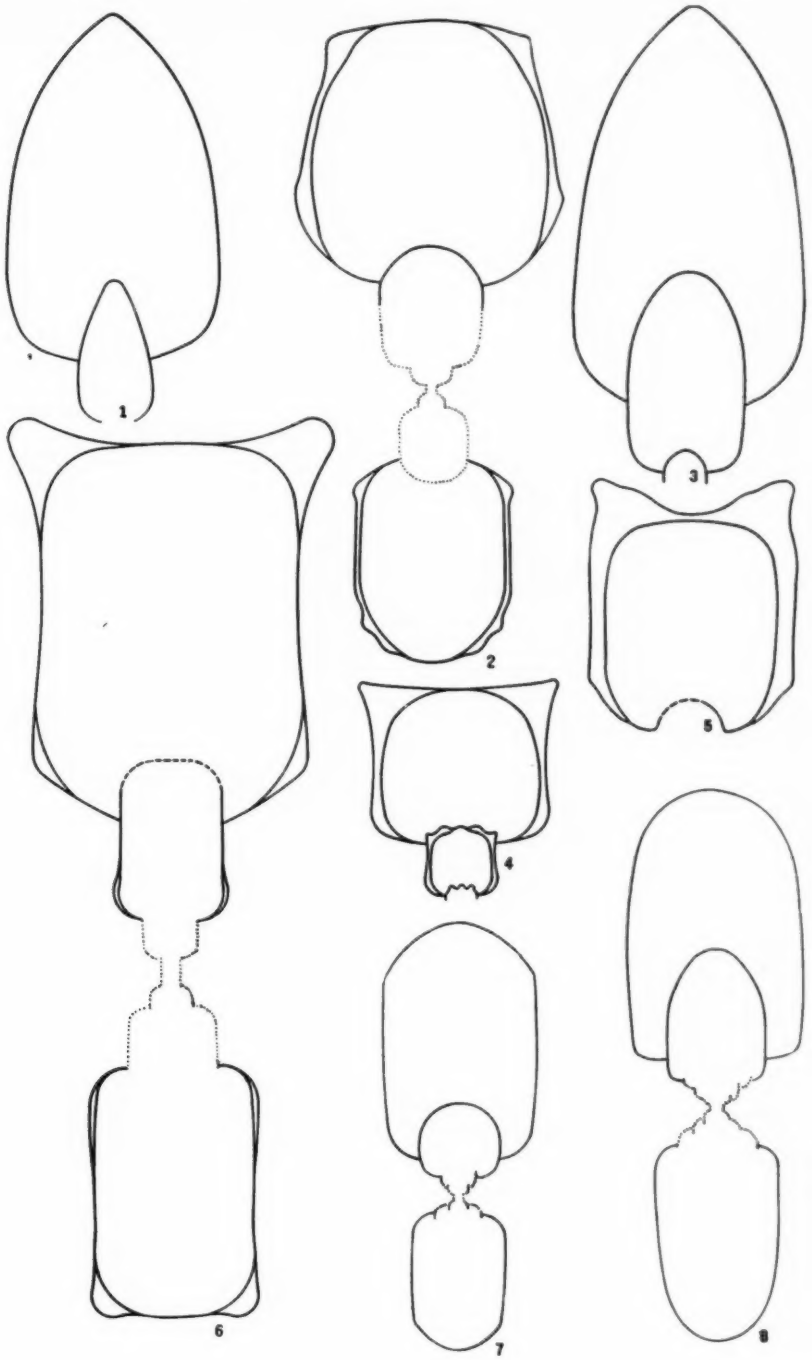
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subquadrate whorl section which remains essentially unchanged thereafter. At a diameter of about 2 mm. the otherwise smooth shell begins to develop a distinct row of pointed, conical lateral nodes, situated about midway between the ventral margin and the umbilicus. With the change in whorl section this row of nodes migrates ventrally rather rapidly, so that one-half whorl later, at a diameter of 5 mm., they are distinctly ventro-lateral. Soon after the appearance of these nodes a row of median ventral nodes and a row of ventral nodes about midway between these make their appearance. Very low lateral ribs are visible at a diameter of about 5 mm. The ventro-lateral nodes in all stages are more conical and pointed than the others which are considerably elongated longitudinally. At a diameter of about 1.5 cm. each lateral rib shows a slight elevation at the umbilical shoulder. They persist thereafter, finally becoming radially elongate nodes at a diameter of about 4 cm. Many shells begin to develop secondary median ventral nodes between the primary nodes which soon fuse to form a very low keel, which may or may not persist. At a diameter of about 8 cm. the ventral and median ventral nodes, which have been gradually decreasing in prominence, are practically obsolete, but the ventro-lateral nodes increase in size and length, developing into bluntly rounded, horn-like spines in final growth. The suture is rather simple; ventral lobe long and narrow with numerous digitations and simple branchlets on each side; first lateral saddle broad, unequally bipartite; first lateral lobe large, divided by several terminal, digitated branchlets and its lateral margins bearing a few nearly simple branchlets; second lateral saddle broad, not deeply divided; second lateral lobe small, sharply incised; remainder of the elements quite simple. The external suture from a very early stage has developed the essential features of the adult.

Remarks.—The large collection of individuals of this species from two nearby localities in the upper Graneros shale makes possible a complete study of all stages. *Acanthoceras? amphibolum* displays a remarkable ontogenetic development, which may be recapitulated briefly as follows: At a very early stage the smooth shell develops sharp lateral nodes, followed by ventral nodes, median ventral nodes and lateral ribs; the whorl section changes from very depressed and rounded to subquadrate; the median nodes give way to a low keel which may also completely disappear and the ventro-lateral nodes finally become very prominent. One might not suspect a young individual like figure 2, Plate 49 and a mature adult as shown by figure 6, Plate 49, of belonging to the same genus, and certainly not to the same species, if intermediate stages were not available.

The generic assignment of this species to *Acanthoceras* is believed to be unsatisfactory. Young individuals up to 7 or 8 cm. in diameter fall in the limits of this genus in its strict sense, but the marked change in the adult shell indicates that the species has progressed completely out of *Acanthoceras* in its correct and restricted usage. Furthermore, typical *Acanthoceras* is a Cenomanian genus, while the Graneros of Kansas is considered to be Turonian. This fact and the

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EXPLANATION OF PLATE 53

FIGS. 1—Ammonite sp. Side view of a fragment greatly reduced, ×$\frac{1}{8}$. (p. 473)
2—*Eutrephoceras* sp. Back view, ×$\frac{1}{2}$. (p. 473)
3–5—*Tragodesmoceras bassi* Morrow, n. sp. 3, Suture of holotype (Pl. 52, figs. 1*a–c*), ×$\frac{3}{4}$. 4, Side view of fragment from the Greenhorn of Colorado, ×$\frac{1}{4}$. 5, Side view of small Kansas specimen at stage in which strong ribs are developed, ×$\frac{1}{2}$. (p. 468)
6—*Mammites rectangulus* Morrow, n. sp. Side view of holotype, ×$\frac{3}{8}$. (p. 468)
7—*Baculites* sp. Side view, ×$\frac{1}{2}$. (p. 473)

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clear ontogenetic development of the species suggests that it has developed directly out of true *Acanthoceras*. .

Type.—From the upper Graneros shale, south bank of Smoky Hill River south of Wilson, Ellsworth County, Kansas. It is very common locally in concretionary masses associated with *Borissjakoceras reesidei*.

Genus BACULITES Lamarck

BACULITES CALAMUS Morrow, n. sp.

Plate 49, figures 8*a*, *b*

Shell of medium size for the genus, rather rapidly tapering, with compressed ovate cross section; surface showing numerous evenly spaced, low, rounded undulations which lie transverse to the length of the shell, strongest on the antisiphonal side and dying out rather abruptly about midway between venter and dorsum. The suture is quite simple with the elements not deeply divided.

Remarks.—This species differs strikingly from its associate, *Baculites gracilis* Schumard. The surface ornamentation of *B. calamus* is coarser, more widely spaced and not oblique, and the shell is more compressed and tapering. It is easily distinguished from the numerous larger species of the Niobrara and Pierre by the characters given above.

Type.—Holotype from the upper Bridge Creek member (Pfeifer) of the Greenhorn formation, sec. 14, T. 23 S., R. 42 W., Hamilton County, Kansas.

BACULITES sp.

Plate 53, figure 7

Several rather poorly preserved specimens of a species of *Baculites* have been found in the Smoky Hill member of the Niobrara formation. The specimen figured shows a part of the suture and the surface ornamentation. There are faint curved undulations on the sides, with no suggestion of nodes. This species appears to be most like *Baculites ovatus* Say. These specimens are interesting as they constitute the first printed record of this genus from the Niobrara of Kansas.

From the "Pyramids" near Fort Monument, Trego County, Kansas.

AMMONITE sp.

Plate 53, figure 1

A fragment of a very large undeterminable ammonite from the Smoky Hill member of the Niobrara formation deserves mention. Ammonites are extremely rare in the Niobrara of Kansas, though poorly preserved specimens of five species have been found. This specimen, which is probably close to *Pachydiscus*, appears to be undescribed. The shell had a diameter of at least 50 cm. It shows at the ventro-lateral margin prominent, rounded, closely spaced nodes which give rise to straight ribs on the flanks. About one-half of these ribs cross the flank to the umbilical shoulder where they become somewhat raised into elongate nodes. The other ribs disappear about halfway down the flank.

Figured specimen from the NW. ¼ sec. 15, T. 15 S., R. 32 W., Logan County, Kansas.

Genus EUTREPHOCERAS Hyatt

EUTREPHOCERAS sp.

Plate 53, figure 2

A single fragmentary nautiloid which probably belongs to the genus *Eutrephoceras* was found in the chalk of the upper Smoky Hill member of the Niobrara formation. The septa are not preserved and the specimen is of value only in showing the presence of this nautiloid in the Kansas area.

From the NE. ¼ sec. 2, T. 3 S., R. 20 W., Phillips County, Kansas.

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OSTRACODA FROM THE AMSDEN FORMATION OF WYOMING

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ABSTRACT

The ostracode fauna of the Amsden formation of the Wind River Mountains is described. Twelve genera and seventeen species are recognized. One new genus, *Balantoides*, is described. Only one established species, the ubiquitous *Paraparchites nicklesi*, is recognized. A species of *Sansabella* is described in which the overlap of the valves is the opposite of the normal overlap of the genus. The age of the fauna is about Ste. Genevieve.

The two localities at which most of the ostracodes described in this paper were collected are called Cherry Creek and Amsden Hill, and are the same localities from which most of Branson and Greger's megafossils came (1). The Cherry Creek locality is about 2 miles south of the Little Popo Agie River along the strike of the beds and the Amsden Hill locality is about 4 miles southeast of the same river.

At the Cherry Creek locality the fossils were not found in place and there was no evidence of zoning indicated by the collections. At Amsden Hill the float indicated the presence of a highly ferruginous red shale underlain by more highly ferruginous purplish limestone. No fossils were found in place, but the ostracodes collected from the float of these two members indicated a zoning of the fossils. The purple limestone contains the same ostracode fauna as the Cherry Creek material. The red shale, which is referred to as the middle red member, contains a different group of ostracodes from those of the purple limestone. The two faunas evidently represent different facies.

On the basis of the megafossils Branson and Greger established the Late Mississippian age of the Amsden, and they correlated it with the Ste. Genevieve formation of the Mississippi Valley. The ostracode fauna indicates that it is about Ste. Genevieve in age. The absence of the common Chester forms, such as *Amphissites* cf. *tricollina* and *Glyptopleurina*, indicates that the Amsden is older than Chester. The species of *Hollinella*, which is similar to some of the Pennsylvanian species, and the abundance of *Sansabella* suggest that the Amsden is younger than Spergen. This would make it about Ste. Genevieve in age. It must be remembered, however, that comparatively little on ostracode faunas of this period has been published and, therefore, it is not easy to make exact correlations.

SYSTEMATIC DESCRIPTIONS

Family LEPERDITELLIDAE Ulrich and Bassler, 1923

Genus PARAPARCHITES Ulrich and Bassler, 1923

PARAPARCHITES NICKLESI (Ulrich)

Plate 54, figure 8

Leperditia nicklesi ULRICH, *1891*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 200, pl. 18, figs. 1*a–e*.

Paraparchites nicklesi GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 105, pl. 9, figs. 2–5.—HARLTON, *1929*, Am. Jour. Sci., vol. 18, p. 255, pl. 1, fig. 1.—MOREY, *1935*, Jour. Paleontology, vol. 9, no. 4, p. 317, pl. 28, fig. 26.

This species is abundant in the Amsden of Dinwoody Canyon where the formation is mostly limestone. Few other species are present in the material collected there. There are both long and short forms of *P. nicklesi* present, differing from each other only in relative length. A very large specimen of the genus *Paraparchites* and apparently referable to this species was found in the purple limestone of Amsden Hill.

Length, 1.2 mm.; height, 0.8 mm.; thickness, 0.44 mm.

Hypotype.—Univ. Missouri, 0.1025–1.

Occurrence.—Common in the Amsden formation in Dinwoody Creek Canyon, Fremont County, Wyoming.

Genus SANSABELLA Roundy, 1926

SANSABELLA AMSDENENSIS Morey, n. sp.

Plate 54, figure 17

Carapace of medium size, subovate in lateral outline; dorsal margin gently and evenly convex; ventral margin broadly and evenly convex, merging with end margins; posterior end broadly and evenly rounded, extremity just above mid-line; ventral portion of anterior margin more flatly curved than dorsal portion giving it a slightly truncate appearance; hinge straight, slightly impressed, equal to slightly more than three-fifths greatest length of carapace; anterior extremity above mid-height, posterior extremity at or below mid-height, cardinal angles evenly rounded; left valve much larger than right and strongly peripheral on all edges, especially on the dorsal and ventral edges; posterior half of carapace compressed, maximum thickness in front of mid-length giving carapace in dorsal view a wedge-shaped outline; anterior half of carapace inflated, with a prominent shoulder where the lateral and anterior surfaces unite; narrow shallow sinus behind mid-length runs from below the dorsal contact, slightly backward to just below mid-line; surface of carapace smooth.

Length, 1.08 mm.; height, 0.8 mm.; thickness, 0.5 mm.

Syntypes.—Univ. Missouri, 0.1028–3.

Occurrence.—Abundant in the Amsden formation of Cherry Creek, and in the purple limestone of Amsden Hill, Fremont County, Wyoming.

Remarks.—A growth series of this species shows several interesting changes from early molts to adult stage. In the early molts the typical sansabelloid overlap beginning at the cardinal angles is present; that is, the apparent overlap of the left valve on the right begins just at the dorsal angles and continues more or less evenly on the end margins. In the adult of *S. amsdenensis* the overlap under the dorsal angles shows a slight tendency toward greater strength than in typical species of the genus. The dorsal margin of the smaller right valve in both young and adult is straight, the dorsal margin of the left valve in the young molt is slightly arched but in the adult it becomes conspicuously arched.

The adult molts vary considerably in size and shape. A large number have comparatively smaller left valves than is found in the normal specimens. There are all gradations between the extremes. On one adult specimen a fairly deep and distinct sinus was observed.

SANSABELLA? DUBIA Morey, n. sp.

Plate 54, figure 21

Carapace rather large; dorsal margin straight, cardinal angles low and rounded subequal; anterior and posterior ends broadly rounded; extremities, subequal in height, situated just above mid-height; ventral margin broadly and evenly convex, merging gradually with end margins; maximum thickness central; maximum height at mid-length; shallow sinus runs from dorsal margin to mid-height; sinus widens toward top and bottom and narrows at middle, merges with surface of valves at both ends; left valve larger than right, overlapping it slightly on free edges; left valve strongly peripheral to right on ventral edge; smooth low ridge formed by very slight expansion of valve parallels ventral edge of each valve; surface of carapace smooth, sloping more or less evenly to each end from center.

Length, 1.0 mm.; height, 0.69 mm.; thickness, 0.5 mm.

Holotype.—Univ. Missouri, 0.1028–2.

Occurrence.—Amsden formation, Cherry Creek, Fremont County, Wyoming. Only one specimen was found.

SANSABELLA REVERSA Morey, n. sp.

Plate 54, figure 6

Carapace subovate in lateral outline; strongly inflated; dorsal margins of valves gently convex, that of right valve more so than that of left; ends broadly rounded; anterior extremity well above mid-height; posterior extremity below mid-height; ventral margin broadly convex; maximum height and thickness in front of mid-length; dorsum channeled, most strongly so in anterior half; hinge straight, equal to about five-eighths length of carapace; valves strongly convex, sides curving strongly to anterior margin and evenly and gently to posterior margins; right valve much larger than left and peripheral to it on all margins, slightly so on dorsal margin, strongly so on ventral margin; overlap on free margins strong, particularly so on ventral margin; surface of carapace finely granular.

Length, 0.86 mm.; height, 0.6 mm.; thickness, 0.45 mm.

Holotype.—Univ. Missouri, 0.1027–2.

Occurrence.—Amsden formation. Abundant. More than 200 specimens collected from sample on Cherry Creek and more than 250 from purple limestone on Amsden Hill, Fremont County, Wyoming.

Family KLOEDENELLIDAE Ulrich and Bassler, 1923

Genus JONESINA Ulrich and Bassler, 1908

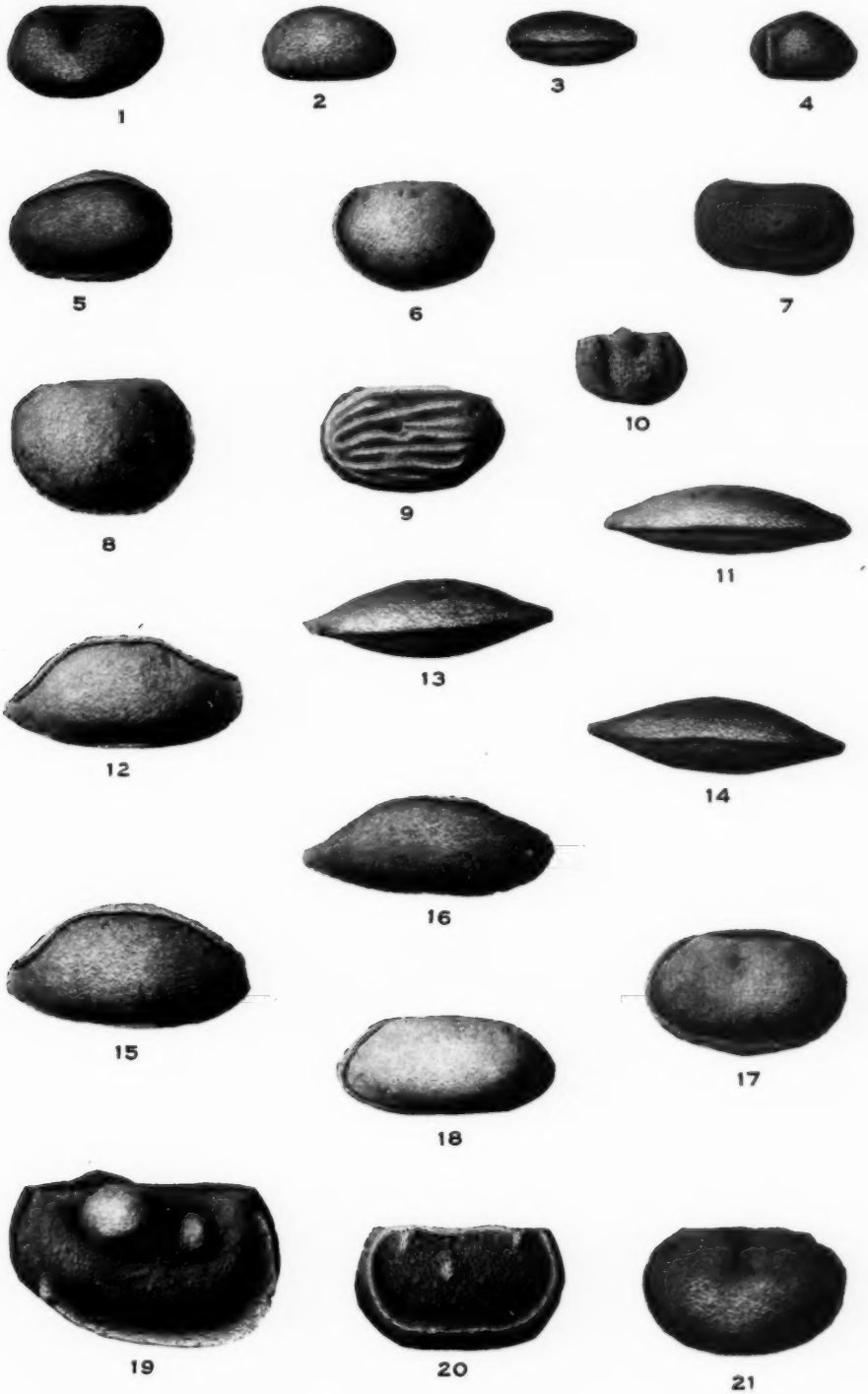
JONESINA? PUNCTA Morey, n. sp.

Plate 54, figure 1

Carapace of medium size, with distinct backward swing; dorsal margin straight;

EXPLANATION OF PLATE 54

FIGS. 1—*Jonesina puncta* Morey, n. sp. Right valve view of holotype, ×20. (p. 476)
2, 3—*Bythocypris amsdenensis* Morey, n. sp. 2, Right valve view of holotype. 3, Dorsal view of holotype. ×20. (p. 481)
4—*Healdia ornata* Morey, n. sp. Right valve view of syntype, ×20. (p. 481)
5—*Cytherella bransoni* Morey, n. sp. Left valve view of holotype, ×20. (p. 482)
6—*Sansabella reversa* Morey, n. sp. Left valve view of holotype, ×20. (p. 476)
7—*Amphissites warei* Morey, n. sp. Right valve view of syntype, ×20. (p. 477)
8—*Paraparchites nicklesi* (Ulrich). Left valve view of hypotype, ×20. (p. 475)
9—*Glyptopleura multicostata* Morey, n. sp. Right valve view of holotype, ×20. (p. 477)
10—*Balantoides quadrilobatus* Morey, n. gen. and sp. Left valve view of holotype, ×20. (p. 479)
11, 12—*Bairdia contracta* Morey, n. sp. Left valve view of holotype, ×20. (p. 480)
13, 15—*Bairdia nasuta* Morey, n. sp. Left valve view of holotype, ×20. (p. 480)
14, 16—*Bairdia delicata* Morey, n. sp. Left valve view of holotype, ×20. (p. 480)
17—*Sansabella amsdenensis* Morey, n. sp. Right valve view of syntype, ×20. (p. 475)
18—*Acratia disjunctus* Morey, n. sp. Right valve view of holotype, ×20. (p. 481)
19—*Hollinella typica* Morey, n. sp. Left valve view of holotype, ×20. (p. 479)
20—*Amphissites robertsi* Morey, n. sp. Left valve view of syntype, ×20. (p. 478)
21—*Sansabella? dubia* Morey, n. sp. Right valve view of holotype, ×20. (p. 476)



Morey, Mississippian Ostracoda

ventral margin broadly convex, inclined toward posterior; ends rounded, anterior extremity above mid-line of valves, posterior extremity below mid-line of valves; hinge straight, equal to about five-eighths length of carapace; dorsal surfaces of valves rounded, equal in height; outline of carapace in dorsal view subovate, maximum thickness at mid-length about one-fourth height of carapace from ventral margin; sides slope away rather flatly from position of greatest convexity of valves; median sulcus ends at approximately mid-height and near dorsal margin, deep at ventral end, becoming shallower toward dorsal margin, losing definition entirely before reaching it; walls of sulcus rather flat, sloping at an angle of about 45 degrees; a very slight sulcus present in some specimens just in front of posterior dorsal angle; surface of carapace finely reticulate, most noticeably so in immature specimens.

Length, 0.82 mm.; height, 0.5 mm.; thickness, 0.4 mm.

Holotype.—Univ. Missouri, 0.1026–3.

Occurrence.—Fairly common in the Amsden formation in the purple limestone on Amsden Hill and on Cherry Creek, Fremont County, Wyoming.

Family GLYPTOPLEURIDAE Girty, 1910

Genus GLYPTOPLEURA Girty, 1910

GLYPTOPLEURA MULTICOSTATA Morey, n. sp.

Plate 54, figure 9

Carapace of medium size; hinge straight; ventral margin broadly and gently convex; posterior end broadly rounded, extremity at mid-line of valves; anterior end narrowly rounded, extremity well above mid-line; rib parallels edges, strongest along dorsal edge, absent between anterior dorsal angle and anterior extremity; rib separated from edges by wide slightly concave border; four long sinuous ribs cross carapace from position of greatest thickness in anterior half to submarginal ridge at posterior end; ridges converge slightly toward posterior; three short ribs on each valve, one on posterior half of valve above upper one of four ridges; another on anterior half of valve between upper two of four long ribs; another in central half of carapace on ventral side below lowest of four long ribs; pit located just behind and above center and between upper two long ribs; submarginal ridge present on ventral and posterior edges; anterior hinge process strong, posterior hinge process weak; surface of carapace between position of maximum thickness and anterior end unornamented; maximum height in front of mid-length.

Length, 1.0 mm.; height, 0.6 mm.; thickness, 0.45 mm.

Holotype.—Univ. Missouri, 0.1026–4.

Occurrence.—Rare in the Amsden formation at Cherry Creek and in the purple limestone on Amsden Hill, Fremont County, Wyoming. Four specimens were found, two on Amsden Hill and two on Cherry Creek.

Family KIRKBYIDAE Ulrich and Bassler, 1923

Genus AMPHISSITES Girty, 1910

AMPHISSITES WAREI Morey, n. sp.

Plate 54, figure 7

Carapace of medium size; hinge depressed, bordered by wide smooth border on each valve; dorsal margin straight, interrupted in lateral outline by prominent shoulder, which rises slightly above dorsum; ridge-like swelling begins in posterior half and runs dorso-anteriorly, ending in shoulder; ventral margin essentially straight; ends broadly rounded; posterior dorsal angle broadly obtuse, well rounded; anterior dorsal angle obtuse, rounded, but more angular than posterior; kirkbyan pit elongate, about three times width, located below center of valve on lower surface of ridge-like swelling; surface of carapace above swelling depressed to dorsal edge; marginal ridge of moderate size; submarginal ridge strong, with a single row of pits on lower

side; border of moderate width, concave; prominent ridge roughly parallels submarginal ridge, ending anteriorly at dorsal edge of valve just behind end of submarginal ridge, separated from submarginal ridge on anterior half of valve by four rows of pits, on posterior half by three rows of pits; low ridge, about one-half greatest length of carapace, present on surface of each valve parallel to ventral margin and below kirkbyan pit, separated from it by one row of pits; low ridge separated from prominent one at posterior end of low ridge by four rows of pits and from middle of kirkbyan pit forward by two rows of pits; carapace wedge-shaped in dorsal outline, maximum thickness in anterior half; maximum height at prominent shoulder; surface of carapace reticulate.

Length, 0.81 mm.; height, 0.5 mm.; thickness, 0.48 mm.

Syntypes.—Univ. Missouri, 0.1027–1.

Occurrence.—Fairly common in the middle red member at Amsden Hill, rare in the purple limestone at Amsden Hill and rare at Cherry Creek, Fremont County, Wyoming.

AMPHISSITES ROBERTSI Morey, n. sp.

Plate 54, figure 20

Carapace of medium size, subquadrate in lateral outline, with flattened sides; dorsal margin essentially straight; dorsal angles sharp, subequal, slightly more than right angles; ventral margin straight in central portion; two small ridges present, one in front and one behind mid-length; ridges about equal in length, extending downward from dorsal margin for a distance equal to one-fifth greatest height of carapace; ridges formed by slightly raised reticulate portions of valve's surface; low smooth carinas on some specimens in place of ridges; kirkbyan pit subcentrally located, just below mid-height, elongate, length twice width, about size of area covered by four reticulation pits; low, but fairly distinct node above and behind pit; low marginal ridge borders free edges; marginal ridge on right valve separated from strong submarginal ridge by a wide, smooth, concave border and on left valve by a narrow border; frill-like inner ventral carina begins at dorsal angles and roughly parallels submarginal ridge; submarginal ridge separated from frill-like inner ventral carina by row of reticulation pits elongate at right angles to ridge; row of elongate pits present on upper inner surface of inner ventral carina; inner ventral carina forms anterior, posterior and ventral margins in lateral outline; hinge impressed, bordered by wide smooth areas which slope in toward hinge; extreme dorsal surface of each valve made up of two ridges with a narrow groove between, ridges apparently formed by continuation of inner ventral carina and submarginal ridge; outer dorsal ridge bends out at position of anterior and posterior ridges; maximum height in anterior half; maximum thickness below center; surfaces of valves within inner ventral carina reticulate.

Length, 1.0 mm.; height, 0.4 mm.; thickness, 0.4 mm.

Syntypes.—Univ. Missouri, 0.1027–3.

Occurrence.—Fairly common in the middle red member at Amsden Hill, Fremont County, Wyoming.

Genus BALANTOIDES Morey, n. gen.

Carapace subovate to subquadrate in lateral outline; hinge straight, generally impressed; hinge structure like that of *Amphissites;* overlap of right valve on free edges of left fairly strong; three lobes project to or above hinge, central lobe most prominent; posterior lobe sometimes split by sulcus giving rise to quadrilobate appearance; lobes separated by sulci; surface of carapace reticulate.

Genotype.—*Balantoides quadrilobatus* Morey.

Remarks.—This genus has a similar hinge structure to that of the members of the family Kirkbyidae and is, there-

fore, placed in that family. It does not, however, have the smooth border or kirkbyan pit characteristic of the prominent genera of that family. It is related most closely to the genus *Mauryella*, from which it is distinguished by the presence of lobes and intervening sulci rather than true nodes.

BALANTOIDES QUADRILOBATUS Morey, n.sp.

Plate 54, figure 10

Carapace small, trilobate, straight-hinged; hinge almost equal to greatest length of carapace, formed by overlap of right valve on left at ends of hinge line; apparently no overlap along hinge between ends; anterior dorsal angle sharp, very little larger than a right angle; posterior dorsal angle sharp and obtuse; posterior end broadly rounded; anterior margin flattened, gently convex in lower half; ventral margin gently convex, curving up rather abruptly to anterior end; anterior lobe larger than others, close to end margin, sharply defined with straight parallel sides, rising slightly above hinge and extending below mid-height; median lobe largest, well defined, with straight parallel sides, extending from about mid-height to well above hinge; posterior lobe divided by well-defined sulcus, anterior portion extending from just above mid-height to slightly above hinge, with straight parallel sides; posterior portion of posterior lobe fairly well defined in front and merging with surface of carapace behind; anterior sulcus long, with rounded bottom, open at both ends; median sulcus short, with rounded bottom, extending from above mid-height almost to dorsal margin; sulcus dividing posterior lobe about equal in length to median lobe, with rounded bottom, open at upper end; anterior extremity at about mid-height; posterior extremity below mid-height; wide smooth border on each valve along hinge, sloping gently toward hinge; right valve larger than left, overlapping it slightly and evenly on free edges; surfaces of carapace reticulate.

Length, 0.6 mm.; height, 0.39 mm.; thickness, 0.3 mm.

Holotype.—Univ. Missouri, 0.1027–4.

Occurrence.—Rare in the Amsden formation on Cherry Creek and in the purple limestone on Amsden Hill, Fremont County, Wyoming.

Genus HOLLINELLA Coryell, 1928

HOLLINELLA TYPICA Morey, n. sp.

Plate 54, figure 19

Carapace of medium size, subrhomboidal in lateral outline; anterior end obliquely rounded, greatest anterior extension of valves well above mid-line of valves; greatest posterior extension of valves at or below mid-line; dorsal half of posterior margin flattened, appearing truncate in lateral view; ventral margin broadly convex, inclined slightly toward posterior; sulcus behind mid-length of hinge, shallow, extending a little below mid-line of valve; another sulcus behind posterior node, shallow, extending downward to mid-line; anterior node broad and high, extending above hinge; posterior node lower than anterior, small, but well defined and vertically elongate; ridge low, of medium width, extending from angle to angle; frill wide, thick, paralleling free margins from slightly below posterior dorsal angle to ventro-anterior margin; frill on one valve widely separated from frill on opposite valve of closed carapace by wide, concave borders; dorsal surfaces of valves rounded; maximum height in posterior half; maximum thickness through anterior nodes; a single row of fairly regularly spaced tubercles of very small size runs on surface of ridge from angle to angle; general surface of carapace smooth.

Length, 1.2 mm.; height, 0.8 mm.; thickness, 0.44 mm.

Holotype.—Univ. Missouri, 0.1026–1.

Occurrence.—Only one specimen was found in middle red member of Amsden formation on Amsden Hill, Fremont County, Wyoming.

Family BAIRDIIDAE G. O. Sars, 1887

Genus BAIRDIA McCoy, 1846

BAIRDIA CONTRACTA Morey, n. sp.

Plate 54, figures 11, 12

Carapace laterally compressed, subrhomboidal in lateral outline; valves thin; dorsal margin broadly and evenly convex curving without angularity from its juncture with anterior margin to its termination near the posterior beak; anterior and dorsal margins unite to form prominent angularity above the mid-line; this angularity is also the greatest anterior extension of the carapace; ventral margin, with slight sinuosity behind mid-length, broadly and very flatly convex, curving up abruptly to join flattened anterior margin and gently to posterior beak; posterior extremity well below mid-line; sides of carapace gently convex; maximum height and thickness central; hinge-line straight, inclined very slightly toward posterior end, equal to about three-eighths greatest length of carapace; edge of left valve above hinge thick but rounded; overlap along dorsal edge slight; overlap on ends and ventral margin slight, except where the lip on ventral edge of left valve overlaps edge of right valve; lip on left valve thick, hence concavity usually seen in lateral outline of typical *Bairdia* is absent; concavity present on ventral margin behind mid-length, possibly due in part to slight deformity of posterior end; surface of carapace smooth.

Length, 1.1 mm.; height, 0.62 mm.; thickness, 0.35 mm.

Holotype.—Univ. Missouri, 0.1029–5.

Occurrence.—Two specimens were found in the Amsden formation on Cherry Creek, Fremont County, Wyoming.

BAIRDIA DELICATA Morey, n. sp.

Plate 54, figures 14, 16

Carapace elongate and slender; valves thin; hinge a little less than one-third total length of carapace, inclined very slightly toward posterior; dorsal margin broadly arched, gently convex on portion parallel to hinge, essentially straight on anterior dorsal slope, concave on posterior dorsal slope; ends long, posterior end acuminate; anterior end rounded, with slight angulation at point where gently convex anterior dorsal slope meets gently convex anterior margin; anterior extremity at mid-height, posterior extremity fairly well below mid-height; ventral sinuosity slight, ventral lip of left valve thin and poorly developed; overlap of left valve on edges of right slight; sides of carapace gently convex, sloping more or less evenly to ends; surface of carapace smooth.

Length, 1.3 mm.; height, 0.52 mm.; thickness, 0.3 mm.

Holotype.—Univ. Missouri, 0.1029–3.

Occurrence.—Rare in the Amsden formation on Cherry Creek, Fremont County, Wyoming.

BAIRDIA NASUTA Morey, n. sp.

Plate 54, figures 13, 15

Carapace elongate, subrhomboidal in lateral outline; ventral margin broadly convex, flattened along portion where ventral lip of left valve overlaps that of right; dorsal margin arched, anterior dorsal slope almost straight, posterior dorsal slope convex, portion parallel to hinge very gently convex; anterior end long and blunt, margin meeting anterior dorsal slope with slight angularity, anterior extremity above mid-height; posterior beak acute, long, extremity well below mid-height; ends compressed; sides of valves of medium convexity, curving evenly to edges; valves of about equal convexity; maximum height and thickness central; hinge straight, inclined slightly toward posterior end and equal to about three-eighths greatest length of carapace; overlap slight or absent on antero- and ventro-posterior edges and slight on the anterior and posterior dorsal slopes and the ventral sinuosity; muscle scar visible externally as a round rough central area about one-seventh mm. in diameter; surface of carapace smooth.

Length, 1.25 mm.; height, 0.6 mm.; thickness, 0.4 mm.

Holotype.—Univ. Missouri, 0.1029–4.

Occurrence.—Two specimens were found in the Amsden formation on Cherry Creek, Fremont County, Wyoming.

Genus BYTHOCYPRIS Brady, 1880

BYTHOCYPRIS AMSDENENSIS Morey, n. sp.

Plate 54, figures 2, 3

Carapace small; valves thin; dorsal margin arched, anterior slope long and gently convex, posterior slope shorter and sharply down-curved; anterior end of carapace long and tapering toward extremity, end margin rounded; maximum height and thickness behind mid-length; posterior end shorter and more tumid than anterior end; posterior margin meeting ventral margin well below mid-line; extremities just below mid-line; left valve apparently overlaps right slightly on all margins except along hinge; hinge straight, equal to about one-fifth greatest length of carapace, located on postero-dorsal slope; apparently no overlap along hinge; surface of carapace smooth.

Length, 0.7 mm.; height, 0.39 mm.; thickness, 0.3 mm.

Holotype.—Univ. Missouri, 0.1030–1.

Occurrence.—Common in the Amsden formation of Cherry Creek and in the purple limestone on Amsden Hill, Fremont County, Wyoming.

Genus HEALDIA Roundy, 1926

HEALDIA ORNATA Morey, n. sp.

Plate 54, figure 4

Carapace small; dorsal margin well arched, posterior limb essentially straight; anterior end more narrowly rounded than posterior; ventral margin straight over most of length, curving to ends; anterior extremity below mid-height of carapace, posterior extremity above; maximum height and thickness at mid-length; ridge begins at margin in front of hinge and terminates on ventral margin back of mid-length; two short thick spines on ridge, upper spine more prominent; ridge strong, defined in front by shallow groove; rounded marginal ridges present on ends; posterior marginal ridge on left valve much thicker than corresponding ridge on right valve; ridge on each valve ends dorsally at end of hinge and ventrally behind mid-length ridges on anterior margins of valves fairly prominent, that of right valve especially sharp and carinate; anterior marginal ridges end ventrally in front of mid-length, but dorsally ridge on left valve ends well down along anterior margin while ridge on right valve ends at upper end of anterior margin; overlap normal for species of this genus; surface of carapace smooth.

Length, 0.54 mm.; height, 0.4 mm.; thickness, 0.3 mm.

Syntypes.—Univ. Missouri, 0.1029–1.

Occurrence.—Amsden formation on Cherry Creek, Fremont County, Wyoming. Four specimens were found.

Genus ACRATIA Delo, 1930

ACRATIA DISJUNCTUS Morey, n. sp.

Plate 54, figure 18

Carapace elongate, with flattened dorsal and ventral margins, and rather narrowly rounded ends; left valve overlaps right on all margins except along hinge and at extremities; overlap strong only on ventral margin; valves strongly tumid, position of greatest thickness approximately through center; point of maximum convexity of left valve slightly lower than that of right valve giving carapace a distorted appearance in end view; maximum height of carapace at mid-length; anterior end of each valve slightly produced forming "lip-like" extremities on valves; surface of carapace smooth.

Length, 1.2 mm.; height, 0.5 mm.; thickness, 0.5 mm.

Holotype.—Univ. Missouri, 0.1025–2.

Occurrence.—Fairly common at Cherry Creek and in the purple limestone at Amsden Hill, Fremont County, Wyoming.

Family CYTHERELLIDAE

Genus CYTHERELLA Jones, 1849

CYTHERELLA BRANSONI Morey, n. sp.

Plate 54, figure 5

Carapace of medium size, subovate in lateral outline; anterior dorsal slope longer and less sharply curved than posterior; ventral margin broadly and evenly convex; anterior end more broadly rounded than posterior; posterior extremity just above mid-line; anterior extremity at or very slightly below mid-line; anterior half compressed; posterior half inflated, maximum thickness in posterior half, giving carapace a wedge-shaped outline in dorsal view; posterior ends of valves strongly tumid with an impressed posterior contact; larger right valve overlaps left slightly on all margins; surface of carapace smooth.

Length, 0.86 mm.; height, 0.6 mm.; thickness, 0.4 mm.

Holotype.—Univ. Missouri, 0.1030–3.

Occurrence.—Rare in the Amsden formation, occurring only in the middle red member on Amsden Hill, Fremont County, Wyoming.

Remarks.—The specimen described and figured is probably a female. The male differs principally in the absence of the strongly inflated posterior half—the anterior end being proportionately larger—and in the posterior contact not being impressed.

REFERENCE

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JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 6, PP. 483–502, PL. 55, SEPTEMBER, 1935

MICROPALEONTOLOGY AND STRATIGRAPHY OF THE LOWER PENNSYLVANIAN OF CENTRAL MISSOURI

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ABSTRACT

In a study of more than forty sections of Lower Pennsylvanian sediments (Henrietta and Cherokee formations) exposed in central Missouri, microfossils have been obtained in some abundance from more than twenty shale members. The fossil assemblages include representatives of eight phyla, eleven classes, and more than forty genera. The vertical distribution of the microfossils indicates that the sediments were deposited in alternating marine and nonmarine cycles. The common association of certain forms with particular types of sediments is suggestive of the habitats of the different groups of organisms. Correlation of members within the sections studied cannot be based solely on the vertical distribution of genera, but the marked abundance of certain forms in definite shale zones is a valuable aid in the recognition of these zones and of the closely associated limestone and coal members. The contact between the Henrietta and Cherokee formations cannot be defined by the distribution of genera. Hexactinellid sponge spicules, holothurian plates, and plant spore exines are described for the first time from Pennsylvanian sediments in Missouri.

The abundance of microfossils in certain of the Lower Pennsylvanian sediments is common knowledge to students of micropaleontology. The foraminifera have received the attention of many workers. In recent years, ostracodes and conodonts have been obtained in great abundance from Pennsylvanian sediments in Missouri and elsewhere. The numerous contributions in the literature indicate something of the wide geographic and stratigraphic distribution of the microfossils of that period. An examination of the literature shows, however, that the work to date has been primarily the description of new forms. Microfossils have been collected and described from established zones or members of formations. Many such descriptions are based on assemblages taken from a very few restricted locaities. It seems probable that in some cases the collections have been made indiscriminately and labeled merely as to formation or general position vertically within the formation.

The value and necessity of descriptive work in micropaleontology may be appreciated fully, but I believe the chief economic value of the microfossils lies in a detailed knowledge of their stratigraphic distribution. Such knowledge aids materially in making accurate subsurface correlations from well samples, and in correlating closely strata exposed at the surface. Studies of this nature should be made from many fossil assemblages, collected at numerous carefully determined horizons, from as many localities as possible.

With this idea in view, the Lower Pennsylvanian sediments exposed in central Missouri were chosen as the subject of this study. The purpose of the study was to determine the kinds,

relative abundance, and stratigraphic distribution of the microfossils present, and the association of the microfossils with the inclosing sediments. About forty sections exposed in Boone County, Missouri, were examined, measured, and described. Other sections were studied in St. Louis, Callaway, Saline, and Henry counties, Missouri. More than 160 samples of shale were collected from these sections, and the stratigraphic position of each carefully determined. The average size sample taken was one quart.

The shale samples were reduced first to volumes of about one-tenth the original by the boiling and flushing process. The clean, dry residues were reduced further by screening. Nearly all of the microfossils passed through the 1.168 mm. screen, and the majority of specimens was retained on the 0.417 mm. screen. Some tiny forms of ostracodes and foraminifera commonly were abundant in the finer residues.

The microfossil assemblage of each sample was studied first as a unit. A list of genera present and the number of specimens of each were recorded. The following standard was adopted arbitrarily in recording the relative abundance of specimens obtained from each sample: abundant, 10 or more specimens; common, 5 to 10 specimens; rare, 3 or less specimens.

All specimens obtained in this study have been deposited in the micropaleontology collections of the Department of Geology, University of Missouri.

I wish to express appreciation to Dr. E. B. Branson, under whose supervision the investigation was made, and to Dr. M. G. Mehl for advice and criticism and for valuable assistance in photographing specimens and composing plates.

STRATIGRAPHY

The sediments studied include the Cherokee formation and the lower part of the Henrietta formation, both of Early Pennsylvanian age (Des Moines series). These sediments form the surface or are subjacent to the glacial drift and loess throughout northern central Missouri.

The Cherokee is the oldest recognized formation of the Pennsylvanian system in Missouri, and includes sandy shales, coal, fire clay, sandstone, limestone, and conglomerate, which rest disconformably upon the Mississippian limestone. In parts of western Missouri, the formation has a thickness of a little more than 700 feet. The thickness decreases eastward due to overlap eastward, so that in central Missouri only the upper 75 to 200 feet of the formation is present. Several members of the Cherokee have received names of more or less local significance, and these names have been used in this study (see fig. 3). At several places, one or more of these members was traced from one locality to another to insure accurate correlation between outcrops.

The Henrietta formation rests conformably upon the Cherokee. Only the lower part of the Henrietta, the Fort Scott limestone, was studied. The Fort Scott consists of two limestone members which are separated by several feet of variegated shale and a thin coal seam. The lower limestone member, the base of which originally was designated (11) the top of the Cherokee formation, occurs as a series of persistent but discontinuous lenses. Where this member is absent, as it is in many places, the top of the Cherokee cannot be defined clearly.

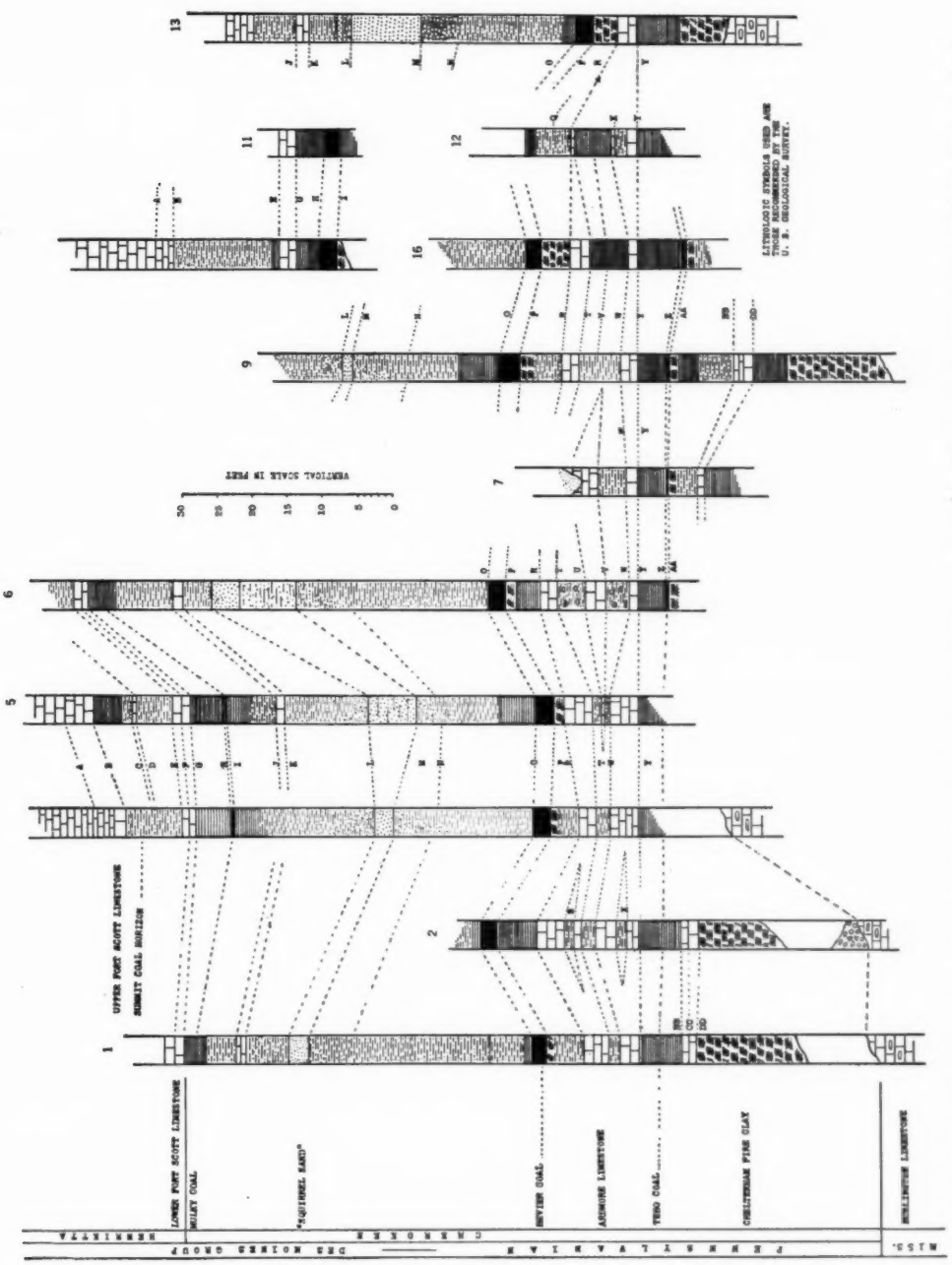

FIG. 1—Vertical sections of Lower Pennsylvanian sediments exposed in central Missouri. Letters indicate horizons at which samples were collected.

In the early reports on the Pennsylvanian of Missouri (13, 14) the limestone member just above the Lexington coal was considered equivalent to the lower Fort Scott limestone of Kansas, and the top of the Cherokee formation in Missouri was drawn at the base of that limestone. Recent work by Greene (9) places the top of the Cherokee in Missouri at the base of the limestone bed which forms the cap-rock of the Mulky coal. This change is based on a study of several hundred well records from western Missouri and eastern Kansas which show rather conclusively that the lower Fort Scott coal of Kansas is the same as the Mulky coal of Missouri, and that the "Mulky cap-rock" is the equivalent of the lower Fort Scott limestone of Kansas (personal communication from F. C. Greene). J. M. Weller and J. B. Knight agree with Greene in this new correlation (personal communications).

The relationships of the correlation formerly accepted, with that proposed by Greene in 1933, are summarized in tabular form as follows:

Classification of Lower Pennsylvanian Rocks in Central Missouri

Hinds and Greene (1915)	Greene (1933)
Upper Fort Scott limestone	"Brown limestone"
	Lexington coal
Lower Fort Scott limestone	Upper Fort Scott limestone
	"Chaetetes limestone"
	"Rhomboidal limestone"
(Top of Cherokee)	
Lexington coal	Summit coal
"Chaetetes limestone"	Lower Fort Scott limestone
	(Top of Cherokee)
Summit coal	Mulky coal
Bevier coal	Bevier coal

The correct determination of the top of the Cherokee formation in Missouri depends upon the accurate identification of the lower Fort Scott limestone member. The correlation of a limestone bed in central Missouri with the lower Fort Scott limestone of Kansas probably can be made with certainty only by tracing the lower Fort Scott limestone member eastward from its type locality at Fort Scott, Kansas, into the Missouri locality. It is beyond the scope of the present study to attempt an exact correlation of this nature, and the writer has followed the recent work of Greene concerning the correlation of the Cherokee formation in Missouri.

DISTRIBUTION OF MICROFOSSILS

Analysis of more than 160 shale samples shows the presence of the following microfossils:

Microfossils obtained from Lower Pennsylvanian rocks of central Missouri.

Foraminifera	12 genera
Ostracoda	11 genera
Conodonts	4 genera
Fish remains	4 genera
Sponges	2 genera
Holothuroidea	2 genera
Plant remains	4 genera
Crinoidea	1 genus
Gastropoda	3 families
Bryozoa	3 genera

Microfossils have been obtained from samples taken at eighteen horizons in the Cherokee formation in central Missouri. The distribution and relative abundance of forms are shown in figures 2 and 3. The microfossils occur chiefly in the shale mem-

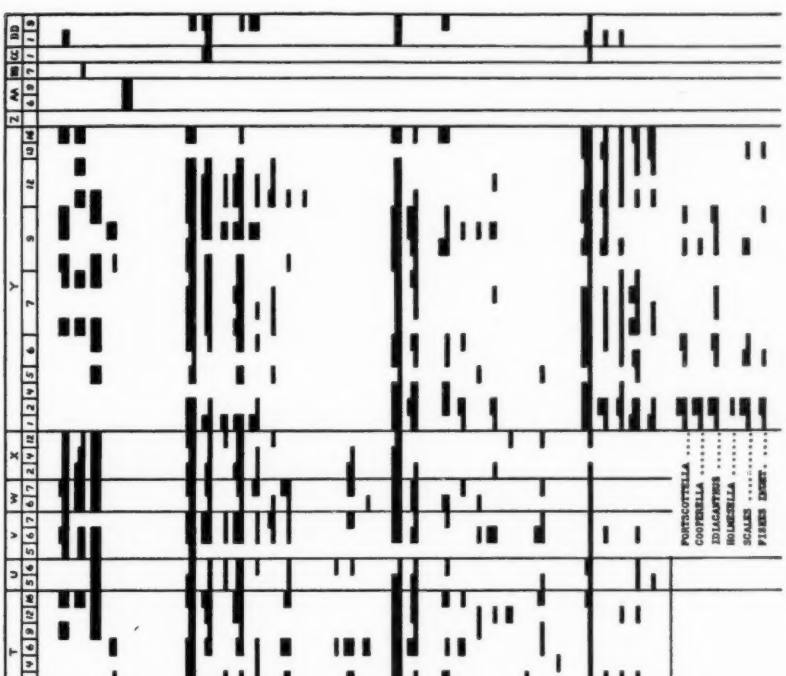

FIG. 2—Chart showing vertical distribution and relative abundance of microfossils obtained from seventy shale samples. Horizons, indicated by letters, are shown in figure 1.

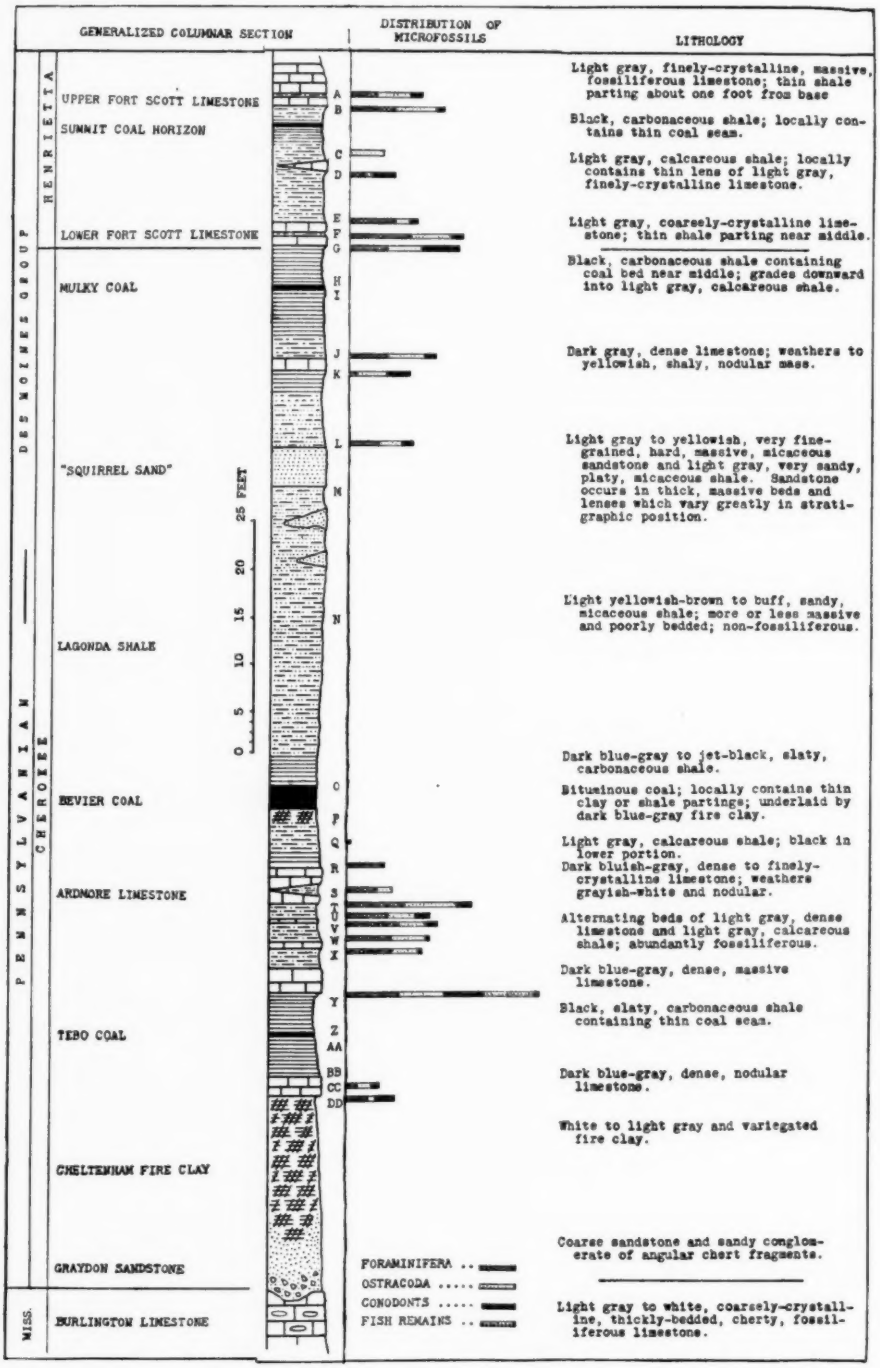
GENERALIZED COLUMNAR SECTION
DISTRIBUTION OF MICROFOSSILS
LITHOLOGY
PENNSYLVANIAN
DES MOINES GROUP
HENRIETTA
CHEROKEE
MISS.
UPPER FORT SCOTT LIMESTONE
SUMMIT COAL HORIZON
LOWER FORT SCOTT LIMESTONE
MULKY COAL
"SQUIRREL SAND"
LAGONDA SHALE
BEVIER COAL
ARDMORE LIMESTONE
TEBO COAL
CHELTENHAM FIRE CLAY
GRAYDON SANDSTONE
BURLINGTON LIMESTONE
0 5 10 15 20 25 FEET
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA BB CC DD
FORAMINIFERA
OSTRACODA
CONODONTS
FISH REMAINS
Light gray, finely-crystalline, massive, fossiliferous limestone; thin shale parting about one foot from base
Black, carbonaceous shale; locally contains thin coal seam.
Light gray, calcareous shale; locally contains thin lens of light gray, finely-crystalline limestone.
Light gray, coarsely-crystalline limestone; thin shale parting near middle.
Black, carbonaceous shale containing coal bed near middle; grades downward into light gray, calcareous shale.
Dark gray, dense limestone; weathers to yellowish, shaly, nodular mass.
Light gray to yellowish, very fine-grained, hard, massive, micaceous sandstone and light gray, very sandy, platy, micaceous shale. Sandstone occurs in thick, massive beds and lenses which vary greatly in stratigraphic position.
Light yellowish-brown to buff, sandy, micaceous shale; more or less massive and poorly bedded; non-fossiliferous.
Dark blue-gray to jet-black, slaty, carbonaceous shale.
Bituminous coal; locally contains thin clay or shale partings; underlaid by dark blue-gray fire clay.
Light gray, calcareous shale; black in lower portion.
Dark bluish-gray, dense to finely-crystalline limestone; weathers grayish-white and nodular.
Alternating beds of light gray, dense limestone and light gray, calcareous shale; abundantly fossiliferous.
Dark blue-gray, dense, massive limestone.
Black, slaty, carbonaceous shale containing thin coal seam.
Dark blue-gray, dense, nodular limestone.
White to light gray and variegated fire clay.
Coarse sandstone and sandy conglomerate of angular chert fragments.
Light gray to white, coarsely-crystalline, thickly-bedded, cherty, fossiliferous limestone.

FIG. 3—Generalized columnar section of Lower Pennsylvanian sediments in central Missouri, showing vertical distribution and relative abundance of microfossils obtained at horizons indicated.

bers closely associated with the limestone beds. Plant spore exines (Trileteae) are the only forms found in the black shales closely associated with the coal beds. No fossils were obtained from the "Squirrel sand" or the Lagonda shale, though these members were sampled in several places.

Foraminifera, ostracodes, and conodonts were about equally represented in abundance of specimens found in samples taken from the fossiliferous portions of the formations. Most of the genera recognized are present in all of the productive members. A few genera, however, appear to be restricted in their vertical distribution. Their discontinuous distribution is probably largely the result of environment. The fish remains apparently are confined to a black shale member in the lower part of the Cherokee formation.

FORAMINIFERA

The Fusulinidae constitute by far the most common group of foraminifera in the Cherokee formation. Dunbar and Condra(8) list *Fusulina meeki* as the only fusulinid genus and species in their collections from the Cherokee formation of Missouri. In my collections from the Cherokee sediments in Boone County, however, there is a variety of fusulinid forms that represent more than one genus and probably several species. No attempt has been made to distinguish the genera of this group. Their study presents a problem to be considered at another time.

The next most abundant form is *Deckerella*, which is represented by several species. The genus ranges throughout the sections studied.

Tetrataxis is third in abundance, and is represented by more than one species. The genus occurs at all but four of the productive horizons.

Other genera commonly present are, in order of their abundance: *Climacammina*, *Polytaxis*, and *Endothyra*.

Bradyina is present at six horizons in the Cherokee, all below the Bevier coal. This genus is present in the Henrietta formation, in the shale member just above the lower Fort Scott limestone.

Globivalvulina occurs in the shale member just below the Ardmore limestone and in the Henrietta formation just below the upper Fort Scott limestone.

Spirillina was found only in two shale members in the lower part of the Cherokee formation.

Orobias was obtained only in the upper Cherokee shales, where it is present at three horizons above the "Squirrel sand."

Paleotextularia is present at four horizons below the Ardmore limestone, and is in the thin shale parting in the upper Fort Scott limestone.

Endothyranella was found only in the light-gray, sandy shale member just above the "Squirrel sand" and in the black shale member just above the Tebo coal.

OSTRACODA

More than half of the ostracodes obtained belong to the genus *Bairdia*. This genus is represented by a large number of species, and is present in some abundance in 57 out of 61 productive samples.

Amphissites is the second most abundant form and is represented by several species. The genus is present in both lower and upper Cherokee sediments, and well-preserved specimens are commonly abundant.

Healdia ranks third in abundance and is sparsely represented by several species at most of the productive horizons. The most common species is *H. formosa* Harlton.

Ulrichia, *Hollinella*, *Bythocypris*, and *Kirkbya* occur rarely at several horizons in both lower and upper Cherokee. These genera are present in greater abundance in the Henrietta shales.

Cytherella was found only in the lower Cherokee, where specimens were obtained from six shale members below the Ardmore limestone and above the Tebo coal.

Sulcella is represented in the Cherokee by one specimen from the shale member just below the Ardmore limestone. One specimen of this genus was obtained also from the Henrietta formation.

One specimen, questionably identified as *Cavellina*, was obtained from the shale member just below the Ardmore limestone. This specimen possibly belongs to the genus *Sulcella*.

Jonesina is represented abundantly in the Henrietta shales just above the lower Fort Scott limestone, but only one specimen was found in the Cherokee formation in Boone County.

CONODONTS

Well-preserved specimens of several genera of conodonts are common in many of the shales of the Cherokee formation.

The genus *Idiognathodus* is represented by a large variety of forms which constitute probably half of the conodonts found. Specimens of this genus were obtained from nearly all productive shale members of the Cherokee, and were found in abundance at three horizons.

Fragments of conodonts, referred to *Hindeodella*, occur in considerable abundance in several shale members in both lower and upper Cherokee.

Streptognathodus is represented rarely in several members of the Cherokee, but is more common in the lower part of the formation.

Trichognathus occurs rarely in several shale members, but is more common in the upper Cherokee shales.

Included under "Conodonts indet." have been placed numerous fragments which previously have been referred to *Lonchodus*, *Prioniodus*, and *Bryantodus*. Many of these specimens doubtless are parts of conodonts which, if complete, would be placed under other genera.

Conodont fragments which consist chiefly of a single denticle, broken at the base, commonly have been assigned to *Prioniodus*. Branson and Mehl (6) have shown that this genus is characterized by the compound nature of the large terminal fang or denticle which extends below the oral bar. This feature cannot be distinguished in many of the broken specimens obtained from the Cherokee sediments, and the writer prefers to place such specimens under "Conodonts indet."

A number of *Bryantodus*-like specimens have been found in the Lower Pennsylvanian sediments. None of the specimens, however, shows the narrow flange-like expansion on both sides of the base, or the downward projection on the inner side beneath the main cusp, features which are characteristic of the genus *Bryantodus*.

FISH REMAINS

A considerable variety of fish remains consisting of minute teeth, scales, and spine denticles was obtained in abundance from the black shale member just above the Tebo coal. These remains were found to be especially abundant in the upper few inches of the shale member, immediately below a massive bed of dark-gray, dense limestone. Samples taken at this horizon, from ten localities in Boone County, produced fish remains in some abundance. The genera *Fortscottela*, *Holmesella*, *Idiacanthus*, and *Cooperella* are recognized. A large variety of scales is present in several samples. Under "Fishes indet." are included numerous specimens which may be teeth, scales, or spine denticles. Many of these forms closely resemble and may be related to Paleozoic fishes described and figured by Newberry (17). Similar forms have been described from the Pennsylvanian of Oklahoma (10). These minute fish remains have received only slight attention, and their study doubtless offers a problem of paleontologic and stratigraphic value.

HOLOTHUROIDEA

A few very small calcareous plates, referred to the fossil Holothuroidea genera *Protocaudina* and *Ancistrum*?, were found in samples from the Cherokee formation in Boone County, and were obtained in abundance from a shale member near the base of the Henrietta formation in Boone, St. Louis, and Callaway counties. These forms are described in another portion of this paper (see page 494).

CRINOIDEA

Several well preserved specimens of minute larviform crinoids were obtained from the shale member near the top of the Cherokee formation, just below the lower Fort Scott limestone, in Boone County. The collection includes several distinct species of the genus *Callimorphocrinus* J. M. Weller.

PLANT REMAINS

Several samples of the black shales closely associated with the coal beds in the Cherokee formation have produced fossil plant spore exines similar to forms previously described and figured (19) as Trileteae. The exines occur in three coal beds in the Cherokee formation in Boone County, and have been found also in samples from Henry and Bates counties, Missouri. This group of fossils is discussed in another portion of this paper (see page 497).

A number of minute, spire-bearing, spherical specimens were secured from a shale member in the upper part of the Cherokee formation at Loc. 1, Boone County. These unique fossils have been described by Peck (18) as Charophyta oogonia of the genus *Gyrogonites*. More than 100 specimens, obtained from three shale samples, constitute the only record of their occurrence in the Cherokee formation.

GASTROPODA

Minute gastropods have been obtained in some abundance from four members of the Cherokee formation. The assemblage includes a variety of high-spired forms of the Pseudozygopleurinae and the Subulitidae, and many low-spired forms of the Trocho-Turbinidae. Many of the specimens are internal molds which do not show generic or specific characters, but many are well preserved and show in detail the delicate surface ornamentation. This group of fossils increases in abundance markedly in the shales of the Henrietta formation.

MISCELLANEOUS

Many of the washed samples left a residue consisting chiefly of calcareous fragments of brachiopod shells, crinoid stem joints, and branching bryozoa. The presence of these remains has been recorded, but no attempt was made to identify the material generically.

ASSOCIATION OF MICROFOSSILS WITH SEDIMENTS

The sediments of the Lower Pennsylvanian in central Missouri offer an excellent opportunity to study the association of microfossils with many types of sediments formed under a wide range of conditions, and to determine something of the habitats of the different groups of micro-organisms.

The microfossils occur in zones which are restricted markedly to the sediments closely associated with limestone beds. The more fossiliferous members are the light-gray calcareous shales and the black carbonaceous shales. There is a notable absence of fossils in the sandstone and fire clay members, and the only forms found in the shales closely associated with coal beds are plant spore exines.

As a whole, the microfossils are about equally abundant in the light- and dark-colored shales, but a closer analysis of the distribution of forms brings out several significant facts. The foraminifera are considerably more abundant in the light-colored shales. No foraminiferal genus was found restricted to the black shales. Two genera, *Globivalvulina* and *Spirillina*, were found only in light-colored

shales. This distribution is in keeping with the concept that the forams flourished best in clear waters. Their modern representatives are much less abundant in estuaries and at the mouths of rivers than in those places where the water is comparatively free from sediment. The abundance of fossil forms in the Cherokee shales probably indicates a very long period of time involved in the deposition of the inclosing sediments. The more abundant foraminifera of the Lower Pennsylvanian sea, including the Fusulinidae, *Tetrataxis*, and *Deckerella*, occur in some abundance also in the black shales. This occurrence possibly signifies that because of their great abundance there were produced individuals which were capable of existing under the less favorable living conditions surrounding the deposition of the black shales.

As a group, the ostracodes are more abundant in the light-colored calcareous shales. A notable exception is the abundance of *Healdia* in the black shales. *Jonesina*, *Cavellina*, and *Sulcella* were found only in the light-colored shales. Modern ostracodes thrive very well under a great variety of living conditions. The occurrence of fossil ostracodes in several types of sediments in the Lower Pennsylvanian bears witness to the varied habitat of this group of animals.

The conodonts, as a group and as individual genera, are strikingly more abundant in the black carbonaceous shales then elsewhere. This common association seems to indicate that these fishes doubtless were scavengers which lived chiefly in brackish and stagnant, unoxygenated waters. It is not uncommon to find more than 100 conodont specimens in a single quart sample of shale. When we realize that each specimen represents probably not more than one two-hundredth of the total bulk of the animals, the remainder of which doubtless was fleshy or chitinous, it is conceivable that in some cases the fleshy portions of these tiny fishes may have contributed in a small part to the organic matter causing the black color of the sediments. The abundance of conodonts in certain strata which have been considered the source beds of petroleum has even led to the suggestion (15) that conodonts may have formed a significant contribution of material suitable for conversion into petroleum.

The fish remains apparently are restricted to a black shale member in the lower part of the Cherokee formation. This occurrence probably indicates that they lived in a habitat similar to that ascribed to the conodonts.

Position of most productive samples.—In nearly all cases the most productive samples were those taken from the upper few inches of the shale members, immediately below the limestone beds. Samples taken lower down in the shale members commonly produced the same fossil assemblage, but a smaller number of specimens. The delicate nature and minute size of the calcareous remains are evidence against a residual accumulation formed by weathering. Their abundance at these horizons need not mean that a greater number of individuals were living in the seas, but more likely signifies a very long time interval during which sediments were accumulating very slowly.

Cyclical sedimentation.—Geologists have long been cognizant of the cycles or rhythms which punctuated geologic time. Barrell, in his classic paper "Rhythms and the Measurements of Geologic Time" (2), cited many examples of cyclical change to be drawn from geologic history. J. M. Weller (23) apparently was the first to apply the theory of cyclical sedimentation to the correlation and interpretation of Pennsylvanian strata. This application has been based largely upon the cyclical occurrence of series of lithologic units, the series separated by unconformities.

In an attempt to apply Weller's "typical Pennsylvanian formation" (23, p. 102) to the Lower Pennsylvanian sediments in Boone County, it was found that many of the cycle members are ab-

sent from this section, and there are no apparent unconformities. No satisfactory subdivision into cycles could be formulated on the basis of lithology. The vertical distribution of marine and nonmarine microfossils, however, strikingly divides the section into a series of alternating continental and marine phases. The continental phases include the coal members and associated black shales from which only plant spore exines were obtained. The marine phases include the fossiliferous limestone members and associated shales, both of which contain marine microfossils. These phases are indicated by the vertical distribution of microfossils, as shown in figure 3.

Subdivisions and correlations.—The distribution of microfossils in the Lower Pennsylvanian sediments in central Missouri offers a means of identifying certain members with considerable accuracy. Most of the genera range throughout the fossiliferous portions of the section, and their discontinuous distribution in the strata is probably largely the result of environmental factors, However, the marked abundance of microfossils at certain horizons aids materially in the recognition of these members. Three outstanding examples are the shale members immediately below the lower Fort Scott limestone, just below the Ardmore limestone, and directly above the Tebo coal. A large number of samples from these shale members, taken at several localities, were consistent in the abundance of microfossils.

The fish remains occur in the black shale member just above the Tebo coal. Not all samples taken from this shale member produced fish remains, but the remains obtained are restricted to the black shale member. The occurrence and abundance of this distinct group of fossils at this horizon is an aid in the identification of the Tebo coal in central Missouri.

Paleobotanical work by David White (25) indicates that the Bevier coal bed corresponds in age with the base of the Allegheny formation of the Appalachian coal fields, and that fossil plants found sparsely in beds below the Bevier coal probably indicate a Pottsville flora. On stratigraphic evidence, the Bevier coal has been correlated with the Murphysboro (No. 2) coal of Illinois, a bed that is certainly at or near the base of the Allegheny formation. Hinds and Greene (14, p. 41) considered the bottom of the Bevier coal the dividing line between lower and upper Cherokee, and suggested that additional paleobotanical work may make it advisable to consider the lower and upper parts of the Cherokee to be separate formations. The vertical distribution of microfossils in the Cherokee somewhat favors this division. *Spirillina*, *Cytherella*, and the fish remains are found

Table showing distribution and relative abundance of microfossils obtained from lower Henrietta, upper Cherokee, and lower Cherokee sediments

	Henrietta (lower part)	Cherokee Above Bevier coal	Cherokee Below Bevier coal
Fusulinidae	a	a	a
Tetrataxis	a	a	a
Polytaxis	r	r	r
Deckerella	a	r	a
Climacammina	c	r	c
Paleotextularia	r		c
Endothyra	c	c	c
Endothyranella		r	r
Orobias		r	
Globivalvulina	r		r
Bradyina	r		c
Spirillina			r
Bairdia	a	a	a
Amphissites	a	a	c
Jonesina	c	r	
Healdia	r	c	c
Kirkbya	r	r	r
Hollinella	c	r	r
Ulrichia	c	r	r
Bythocypris	r	c	r
Cavellina ?			r
Cytherella			c
Sulcella	r		
Idiognathodus	c	c	c
Streptognathodus	r	r	c
Trichognathus	r	c	c
Hindeodella	c	c	c
Fish remains			a

r = rare; c = common; a = abundant

only in the lower Cherokee. Holothuroidea, Charophyta, and *Orobias* are found only in the upper Cherokee. *Paleotextularia*, *Bradyina*, and *Globivalvulina* are common in the lower Cherokee and rare in the Henrietta, but were not found in the upper Cherokee. *Jonesina* occurs commonly in the Henrietta, but only one specimen was found in the Cherokee and none below the Bevier coal. *Bythocypris* occurs commonly in the upper Cherokee, but is very rare in the lower part of the formation. Gastropods and *Hollinella* are present in the Cherokee, but are markedly more abundant in the shales of the Henrietta formation. The vertical distribution and relative abundance is shown in the table on page 493.

CALCAREOUS SPONGE SPICULES AND HOLOTHURIAN REMAINS

The sponge spicules described in this paper were obtained from a thin, calcareous shale member in the lower part of the Henrietta formation, immediately below the lower Fort Scott limestone, St. Louis County, Mo. (Loc. 18).

The sponge spicules described here are composed of crystalline calcite. Broken surfaces of the spicules exhibit well-developed rhomboidal cleavage. When placed in dilute hydrochloric acid, several specimens dissolved completely without leaving any trace of residue. The axial canals have been destroyed in the process of substitution and crystallization. In none of the spicules is their method of union distinguishable.

These spicules are of interest because of their minute size, delicate structure, and excellent condition of preservation. They are comparable in size to the very small types of spicules which are present in the bodies of most modern sponges. Their presence in calcareous, sandy shales, and their association with abundant conodont remains indicates that this group of sponges probably inhabited very shallow waters. This is of interest because the hexactinellid sponges found in modern seas are confined almost exclusively to deeper waters.

HOLOTHURIAN REMAINS

Several shale samples from the Lower Pennsylvanian of Missouri have produced microscopic calcareous perforated plates which doubtless are holothurian skeletal elements. A variety of these plates has been obtained from seven localities and at five horizons in the upper Cherokee and lower Henrietta shales.

DESCRIPTION OF SPECIES

Phylum PORIFERA

Genus ASTERACTINELLA Hinde

ASTERACTINELLA EXPANSA Hinde

Plate 55, figures 5, 10

Asteractinella expansa HINDE, *1888*, Paleont. Soc., Mon. Brit. Pal. Sponges, p. 173. pl. 18, fig. 3. Carboniferous limestone, Ayrshire.

Spicules consist of a variable number of rays which radiate from a common center. Rays are robust, straight or slightly curved, of varying length, and taper sharply to an obtuse point.

Henrietta formation, St. Louis County Mo. (Loc. 18). Univ. Missouri, P3–2 and P3–4.

ASTERACTINELLA GRACILIS Bailey, n. sp.

Plate 55, figures 1–4, 6, 9

Skeletal elements consist of spicules composed of a variable number of unequal rays which radiate from a common center. Rays are cylindrical, smooth, very slender, straight, and taper gradually to sharp points.

The dimensions represented by an average of several individuals are: Greatest dimension, 0.55 to 1.46 mm.; length of rays, 0.22 to 0.88 mm.; diameter of rays at base, 0.06 to 0.17 mm.

The forms assigned to this species are much smaller and more delicate than *A. audnax* J. M. Weller and do not have

swollen rays. The rays are much more slender and are not swollen at the base to produce the massive central body that is characteristic of *A. expansa* Hinde.

Henrietta formation, St. Louis County Mo. (Loc. 18). Syntypes, Univ. Missouri, P3–3 and P3–5.

ASTERACTINELLA CLAVIFORMIS Bailey, n. sp.
Plage 55, figures 7, 11–13

Sponge spicules in which a variable number of unequal rays radiate from a common center. One of the rays is elongated and greatly swollen; the remaining rays are reduced to rounded knobs, giving to the spicule a club-like form.

The dimensions shown by an average of syntypes are: Greatest dimension, 1.11 to 1.84 mm.; diameter of swollen ray, at base of ray, 0.28 to 0.44 mm.; length of swollen ray (incomplete), 0.68 to 1.11 mm.; greatest diameter of spicule, taken through common center (incomplete), 0.73 to 1.11 mm.

This species is somewhat similar to *Hyalostellia diabola* J. M. Weller, but differs in that the latter is a simple hexactinellid spicule with six rays, one or more of which are greatly swollen at the tips, while *A. claviformis* has more than six rays, none of which are swollen at the tip. It is similar to some of the forms assigned to *A. audnax* J. M. Weller but is very much smaller and differs considerably in the length proportion of the rays.

Henrietta formation St. Louis County, Mo. (Loc. 18). Syntypes, Univ. Missouri, P1–2 and P2–3.

Genus THOLIASTERELLA Hinde

THOLIASTERELLA SEXRADIATA Bailey, n. sp.
Plate 55, figures 8, 15, 16

Spicules composed of a straight, smooth, cylindrical shaft which supports at one end six cylindrical, bluntly pointed rays radiating at nearly equal angles to each other and at right angles to the central shaft. The head rays are slightly varied in length and are recurved downward toward the central shaft. A central disc is formed by the union of the bases of the head rays. The entire upper surface of the spicule is finely granular; under surface of central disc and of basal portions of head rays finely granular; under surface of head rays smooth toward the tips.

The dimensions shown by an average of syntypes are: Diameter of central shaft at summit, 0.27 mm.; diameter of head rays at base, 0.27 mm.; length of head rays, 0.66 to 1.24 mm.

This species seems to be similar to *T. trunca* J. M. Weller, but is much larger. Weller's description and figure (24) are not sufficiently detailed to make a closer comparison.

This species appears to be very close to *T. youngi* Hinde, and a close comparison of type specimens might show them to be variations of the same species. Hinde's figures (12) of *T. youngi* show the presence of distinct nodes or blunt spines on the upper surface of his specimens, and the entire under surface is smooth. The upper surface of *T. sexradiata* is finely granular, but does not possess nodes. The central disc of *T. youngi* is more pronounced. Hinde's species is described from Carboniferous limestone of Ayrshire, England. While the differences in these species appear to be minor, they are considered to be of specific value since the specimens occur in different geologic systems and are from localities so widely separated.

Henrietta formation, St. Louis County, Mo. (Loc. 18). Syntypes, Univ. Missouri, P2–1 and P2–5.

THOLIASTERELLA QUINQUESPINA Bailey, n. sp.
Plate 55, figure 14

Spicules composed of a straight, cylindrical shaft which supports at its summit five cylindrical, bluntly pointed head rays radiating at nearly equal angles to each other and at right angles to the central shaft. The head rays are of about equal length and are very slightly recurved downward toward the central

shaft. The entire surface of the spicule is finely granular.

The dimensions of the holotype are: Diameter of central shaft at summit, 0.22 mm.; diameter of head rays at base, 0.27 to 0.29 mm.; length of head rays, 0.74 to 0.77 mm.

This species differs from *T. sexradiata* in having only five head rays. It differs from *T. youngi* Hinde in the absence of nodes or blunt spines on the upper surface, and by the granular under surface. These differences are considered of specific value since the two species occur in different geologic systems, and are from localities so widely separated.

Henrietta formation, St. Louis County, Mo. (Loc. 18). Holotype, Univ. Missouri, P2–2.

Phylum ECHINODERMATA

Class HOLOTHUROIDEA

Family CHIRIDOTIDAE Oestergren

Genus PROTOCAUDINA Croneis

PROTOCAUDINA KANSASENSIS (Hanna)

Plate 55, figures 18–20

Laetmophasma kansasensis HANNA (part), *1930*, Jour. Paleontology, vol. 4, p. 413, pl. 30. Pennsylvanian (Wabaunsee), Kansas.

Protocaudina kansasensis (Hanna) CRONEIS, *1932*, Jour. Paleontology, vol. 6, p. 138, pl. 20, figs. 2, 6. Pennsylvanian (Mineral Wells), Texas.

Calcareous, concavo-convex, fossil holothurian discs with four central holes and ten outer perforations. Rim circular.

The diameter of the disc shown by an average of several individuals is 0.35 mm.

Cherokee shale, Boone County (Locs. 1 and 11), and Callaway County, Mo. (Locs. 19 and 20). Henrietta formation, St. Louis County, Mo. (Loc. 18). Univ. Missouri, E1–1, E1–3, E1–5, E3–2, and E3–3.

PROTOCAUDINA TRAQUAIRII (Etheridge)

Plate 55, figures 17, 21

Cheirodota (?) *traquairii* ETHERIDGE, *1881*, Roy. Phys. Soc. Edinburgh, Proc., vol. 6, p. 196, pl. 6. Upper Carboniferous, Glasgow, Scotland.

Laetmophasma (?) *kansasensis* HANNA (part), *1930*, Jour. Paleontology, vol. 4, p. 413, pl. 40, fig. 3. Permian (Elmdale shale), Kansas.

Protocaudina traquairii (Etheridge) CRONEIS, *1932*, Jour. Paleontology, vol. 6, p. 137, pl. 20. Mississippian limestone, Illinois.

Concavo-convex, wheel-like plates; central space occupied by four somewhat triangular perforations; outer zone subdivided by eight short septa or spokes

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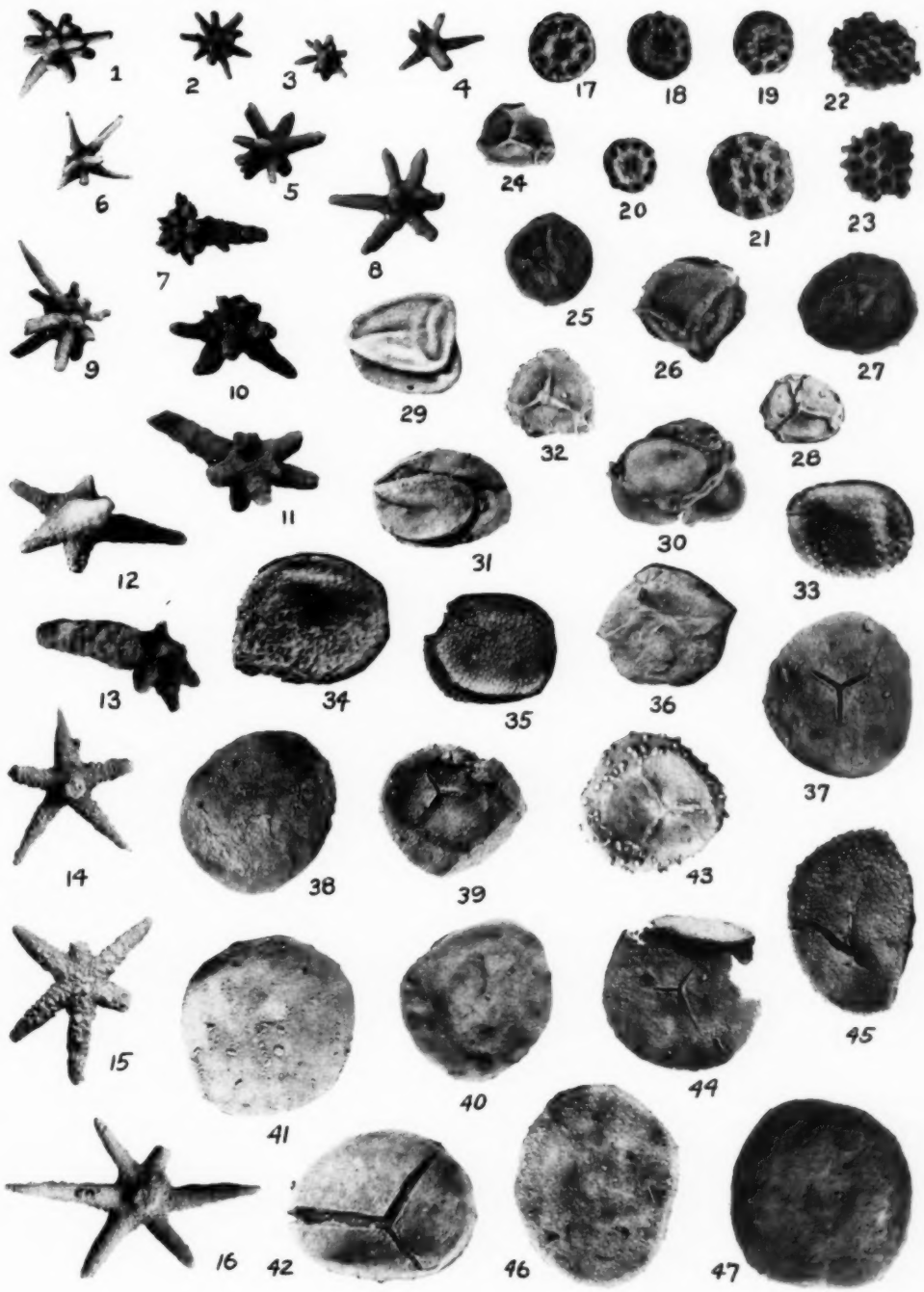
EXPLANATION OF PLATE 55

Figs. 17–23 are enlarged ×20, all others are enlarged ×11. Figs. 1–24 are of specimens from the Henrietta formation, Loc. 18, St. Louis County, Missouri.

FIGS. 1–4, 6, 9—*Asteractinella gracilis* Bailey, n. sp. 2, 9, Syntypes. (p. 494)
5, 10—*Asteractinella expansa* Hinde. (p. 494)
7, 11–13—*Asteractinella claviformis* Bailey, n. sp. 11, 13, Syntypes. (p. 495)
8, 15, 16—*Tholiasterella sexradiata* Bailey, n. sp. 15, 16, Syntypes. (p. 495)
14—*Tholiasterella quinquespina* Bailey, n. sp. Under surface of holotype. (p. 495)
17, 21—*Protocaudina traquairii* (Etheridge). (p. 496)
18–20—*Protocaudina kansasensis* (Hanna). (p. 496)
22, 23—*Ancistrum*? species. (p. 497)
24, 28, 32—*Zonales* species. From Pennsylvanian fill at Loc. 14, Boone County, Missouri. (p. 500)
25, 27, 31—*Laevigati* species. From Mulky coal, Loc. 4, Boone County, Missouri. (p. 500)
26, 36—*Zonales* species. From Bevier(?) coal, Loc. 15, Henry County, Missouri. (p. 500)
29, 37, 38, 40–42, 47—*Laevigati* species. From Tebo coal, Locs. 6 and 9, Boone County, Missouri. (p. 500)
30—*Laevigati* species. Tetrad from Pennsylvanian fill at Loc. 14, Boone County, Missouri. (p. 500)
33, 34, 43, 46—*Apiculati* species. From Pennsylvanian fill at Loc. 14, Boone County, Missouri. (p. 500)
35, 39, 44, 45—*Apiculati* species. From Tebo coal, Loc. 9, Boone County, Missouri. (p. 500)



Bailey, Lower Pennsylvanian Fossils

into a corresponding number of semi-oval perforations. Margin plain.

The diameter of the disc shown by an average of several individuals is 0.35 to 0.48 mm.

Cherokee shale, Boone County (Locs. 1, 6, and 11), and Callaway County, Mo. (Locs. 19 and 20). Henrietta formation, St. Louis County, Mo. (Loc. 18). Univ. Missouri, E1–2, E1–4, E1–5, E3–1, E3–2, and E3–3.

Genus ANCISTRUM Etheridge

The genus *Ancistrum* probably should be restricted to include only the fish-hook-like spicules which merit this Greek designation. The plate material assigned to this genus, when more thoroughly studied, doubtless will be assigned to a number of species and genera.

ANCISTRUM? species
Plate 55, figures 22, 23

The collections from the Lower Pennsylvanian of Missouri include a number of incomplete, perforated, calcareous plates which do not warrant specific designation, but for the present, at least, should be placed in this genus.

The dimensions shown by an average of several individuals are: Greatest diameter, 0.24 to 0.26 mm.; diameter of perforations, 0.044 to 0.077 mm.

Cherokee shale, Boone County (Locs. 1, 6, and 16), and Callaway County, Mo. (Locs. 19 and 20). Henrietta formation, St. Louis County, Mo. (Loc. 18). Univ. Missouri, E2–1, E2–2, E2–3, E2–4, E2–5, E3–2, and E3–3.

FOSSIL PLANT SPORE EXINES

The types of plants of Paleozoic time were considerably different from those of Cretaceous and of Tertiary or of Recent time. The Carboniferous flora consisted largely of pteridospermophytes, *Cordaites*, true ferns, and club mosses. The club mosses, or lycopods, were represented by numerous species of *Lepidodendron* and *Sigillaria*, which were large palm-like plants attaining at times a height of 100 feet and bearing at the top a crown of branches. The cones of both fossil and living lycopods consist of scales arranged around an axis, each bearing on its upper side a spore case, or sporangium, containing spores. This group of plants includes both isosporous and heterosporous families. In the Lycopodiaceae the spores are all of one kind. In the Selaginellaceae, to which the above mentioned plants probably belong, two types of spores are developed, microspores and megaspores. Microspores develop in large numbers in a sporangium and are relatively small. Megaspores are relatively large, and only a few develop in a sporangium. The two types of spores are not distinguishable entirely on the basis of size, but also on their mode of development and function in the living plant. All microspores and most megaspores are developed by fours out of one cell by two consecutive or simultaneous divisions resulting usually in four cells. This division gives rise to a group of four spores which is commonly called a *tetrad*.

During the growth period, the spore walls develop conformable to this tetrasporic grouping. When the spores mature and become hardened and separated, they retain this shape with a ridge along the mutual union of the inner edge of the four spores. The outer spore wall, or exine, bears sculpturings and various processes characteristic of certain genera and species. The spore exines of this group are easily recognized by their triradiate mark or cross. In the process of fossilization, only the hard, cutinized exines of the spores remain as fossils. These should not be called spores, but should be designated as *spore exines*.

Fossil plant spore exines

Early studies.—The presence of spore exines as fossils in coal has been known for many years, but for a considerable time after their discovery they were regarded as sporangia.

In 1833, Witham (26) figured several sections of coal from various localities in

Great Britain. On his Plate 11, figures 4 and 5, are sections of cannel coal from Lancashire which show numerous macrospore exines embedded in the coal. Witham considered them organisms of uncertain nature, but thought them to be "indicative of a monocotyledonous plant." This is apparently the earliest figure or note of the occurrence of fossil exines.

Morris (16) seems to have been the first to figure isolated fossil macrospore exines, though he regarded them as sporangia.

In 1854, Balfour (1) noted and figured the occurrence of microspore and megaspore exines from a coal in Scotland. He called them "seed-like organs," and considered them "spore cases of some plant allied to *Lycopodium*, perhaps *Sigillaria*."

In 1871, Dawson, (7) noted the presence of "spore cases" in slides of coal from Nova Scotia and Cape Breton, and in a brown, bituminous shale of Devonian age at Kettle Point, Lake Huron.

The Trileteae.—In 1884, Paul Reinsch published two extensive volumes entitled "Micropalaeophytologia" (19) in which he described generally and figured more than 600 exines of microspores and megaspores found in coals of central Russia and Saxony. He considered the entire group algae because of their great range in size and assigned to them the general name *Trileteae.*

Reinsch recognized four distinct shapes of exines, and classified his unnamed specimens in the following divisions:

Trileteae

Subtribus I.	Nucleus triangularis
Subtribus II.	Nucleus semi-ellipticus
Subtribus III.	Nucleus ellipticus
Subtribus IV.	Nucleus orbicularis

Bennie and Kidston (5) described megaspore exines from the Carboniferous formation of Scotland, and compared them with the spores of some recent plants. They were able to recognize four distinct types of exines in their collections, and they established four divisions under the general group name *Triletes.* Bennie and Kidston did not classify their specimens on the basis of shape, as did Reinsch, but they recognized differences of surface ornamentation and structural features. Their general scheme of classification is as follows:

Triletes, Reinsch

Division I.	Laevigati
Division II.	Apiculati
Division III.	Zonales
Lagenicula, Kidston (New Group)	

Concerning the use of *Triletes* as a genus, these authors say (p. 91):

> *Triletes* must not be regarded as a genus, for the occurrence of the triradiate ridge, one of the chief characeristics of the group, though common to the spores of the Lycopodiaceae, also occurs on the spores of other orders (as on the spores of Sphagnum, etc.).

Species names were not assigned to the exines in their collection, but the specimens were designated as *Triletes* I, *Triletes* II, etc., and the numbering was continuous from I to XVIII throughout their three divisions.

Seward (20) proposes to retain the name *Triletes* as a convenient designation for isolated fossil spore exines presumably belonging to Lepidodendraceae and allied families, but not definitely associated as yet with fossils of these plants. Used in this manner, the name *Triletes* probably covers many genera, belonging to several families.

In his microscopic studies of coal, Thiessen found that microspore and megaspore exines are quite common in many coal beds in North America. He discussed (21, 22) the occurrence and general distribution of the exines of several coals and figured several kinds, but did not name or attempt to classify the forms. His views concerning the use of names for isolated exines are expressed in the following statement (22, p. 71):

> To try to give a definite name to them, without knowing their affinities and relationships, as has been done by some in the past,

would be a waste of time and space. . . . When their relationships are known proper names will be given them.

At the same time, however, Thiessen shows convincingly that correlation of coals may be established through a comparison of the characteristic spore exines contained. How such work is to proceed easily without having a convenient nomenclature for the exines is not evident.

In 1928, Bartlett (3) described megaspore exines obtained from coal pebbles found in glacial drift in Michigan. He recognized three types of exines which he described under the name *Triletes*, and to which he assigned species names. These three species apparently constitute the only specific descriptions of fossil spore exines of the Trileteae from North America, and by so naming his specimens, Bartlett was the first to apply binomial designations to exines of this group.

In a discussion of the genus *Triletes* Reinsch, Bartlett (4) explains that the study of isolated spores gives phytogeographic and floristic information of value even though their definite association with plants is not known.

Since 1930, numerous spore exines from coal beds in Europe have been described by Zerndt, Potonie, and Kowalewska-Maslankiewiczowa. These authors have regarded *Triletes* as a genus, and have followed Bartlett in assigning species names to the specimens described by them. They have recognized also the divisions established by Bennie and Kidston, and have classified their species according to these divisions.

Need for a classification

If spore exines are to be of any value in making stratigraphic correlations of coal beds, a convenient nomenclature for them must be established. Bartlett (4) has shown the utility of naming species of other groups of organisms, such as the Fungi Imperfecti, of which the relationships are not definitely known. This practice has been accepted generally by students of micropaleontology working with the conodonts. The term Trileteae, as used by Reinsch, includes all extinct spore exines possessing the triradiate ridge. His classification of the exines, based on the shape of the outline of the compressed exine, is purely artificial. The divisions established by Bennie and Kidston on the basis of surface ornamentation and structural features constitute a more natural classification. The constant differences in surface ornamentation are important in the recognition of exine types characteristic of certain coals. These distinct differences constitute a basis on which genera and species can be established. Until definite relationships can be established between the types of fossil exines and the plants by which they were produced, it seems advisable to use the name Trileteae as a group term to include all fossil exines possessing the triradiate ridge. When relationships become known the placing of genera and species in their proper families and order will follow.

Fossil spore exines from Missouri

In a study of the microfossils of the Lower Pennsylvanian (Cherokee formation) of central Missouri, fossil plant spore exines have been obtained in some abundance from five localities and from three coal members.

Occurrence.—The spore exines were obtained as isolated specimens from washed samples of weathered coal taken from the outcrops. No other fossils were found associated with the exines. Some of the best specimens were obtained at Loc. 14, where they occurred in a black gritty shale which forms a sink hole or channel fill deposit at the base of the Pennsylvanian section.

Preservation.—All of the specimens obtained have been crushed by the weight of the enclosing sediments so that the exines occur as irregularly flattened discs. The crushing commonly has caused the specimens to become broken along the

ridges on the upper surface, giving rise to a triradiate crack in the exine. Seen in cross section, the discs appear as compressed rings. The exines are preserved as hard, brittle, carbonaceous material which burns to a white ash in an open tube. They are dark-brown to black in color, due probably to staining, and many of the specimens present a glistening surface in reflected light. In transmitted light they are very slightly translucent and are a dark amber color.

Description of types.—Three distinct types of exines are readily recognizable in the collection from central Missouri.

(1) *Laevigati.*—Exines of this type possess a smooth surface, unornamented except for the triradiate ridge on the upper surface. The specimens occur as compressed discs which commonly measure 1.44 to 1.64 mm. in diameter. Some smaller specimens, which average about 0.6 mm. in diameter, probably represent microspore exines of this type.

This smooth type of exine is by far the most abundant form in the collections from the Cherokee formation in central Missouri. They have been obtained in considerable abundance from the Tebo coal at Locs. 6 and 9, and from the Mulky coal at Loc. 4. Several specimens were obtained from the black shale fill at Loc. 14.

(2) *Apiculati.*—This type of exine is characterized by the presence of mamillate spines regularly or irregularly distributed on the outer surface. Some forms are almost smooth, others have only a few scattered spines, while others bear numerous short conical spines. The triradiate ridge is prominent on the upper surface. The constant variation in number, size, and distribution of the spines probably will constitute a basis for establishing species of this type when an adequate collection of such exines can be studied.

A few exines of this type were obtained from the Tebo coal at Loc. 9. Several specimens were obtained from the black shale fill at Loc. 14.

(3) *Zonales.*—Exines of this type are obscurely triangular in outline, usually surrounded by a gently undulating equatorial zone which is either solid or divided into a number of pedicle-like branches supporting the peripheral region. The triradiate ridge is very prominent, extending from the center of the upper surface of the exine to the border of the zone where it becomes slightly pointed, thus imparting to the complete exine its triangular outline. The surface is either smooth, or is ornamented by a few irregularly scattered spines. The equatorial zone seldom is preserved on isolated exines obtained from coal beds, but its former presence usually is indicated along the margin of the central body of the exine.

A few exines of this type have been obtained from the Bevier (?) coal at Loc. 15. None have been found in the Mulky or Tebo coal members. Several specimens were found in the black shale fill at Loc. 14.

Collection.—All of the specimens obtained have been deposited in the micropaleontology collections of the University of Missouri, under the following catalog numbers: *Laevigati*, 31008–1, 31008–5, 31010–5, 31010–2, 31010–3, 31010–4; *Apiculati*, 31009–1, 31009–2, 31009–4; *Zonales*, 31008–1, 31008–4.

Register of Localities

(1) Boone County, Mo.: 1 mile east of Columbia; complete section of Cherokee formation exposed in clay pits and small valley just south of office of Edwards-Conley Brick Company. S. ½ sec. 8, T. 48 N., R. 12 W.

(2) Boone County, Mo.: three-fourths of a mile east of Columbia; lower limestone members of Cherokee formation well exposed along east bank of Hinkson Creek, in bluff below Boy Scout Cabin. W. ½ sec. 8, T. 48 N., R. 12 W.

(3) Boone County, Mo.: 2½ miles east of Columbia; lower Fort Scott limestone exposed in several outcrops along both banks of Hominy Branch, just south of U. S. highway No. 40. NW. ¼ sec. 10, T. 48 N., R. 12 W.

(4) Boone County, Mo.: 3 miles northeast of Columbia; lower Henrietta and upper

Cherokee members well exposed in several outcrops along large valley that joins Hinkson Creek from the east. S ½ sec. 33, T. 49 N., R. 12 W.

Lower part of Cherokee formation exposed in road cut along south bank of Hinkson Creek. N. ½ sec. 33, T. 49 N., R.12 W.

(5) Boone County, Mo.: 4 miles northeast of Columbia; Cherokee formation well exposed in a series of outcrops along the south of Hinkson Creek. SE. ¼ sec. 28, T. 49 N., R. 12 W.

(6) Boone County, Mo.: 4½ miles northeast of Columbia; Cherokee formation well exposed along both banks of large stream which joins Hinkson Creek from the east. Locality includes an exposure of highly tilted strata. NE. ¼ sec. 27, T. 49 N., R. 12 W.

(7) Boone County, Mo.: 5 miles northeast of Columbia; lower portion of Cherokee formation exposed in several valleys just north and west of Gillaspie School. NW. ¼ sec. 26, T. 49 N., R. 12 W.

(8) Boone County, Mo.: 6 miles northeast of Columbia; about 50 feet of Graydon ? sandstone exposed in a bluff along the south side of Hinkson Creek. S. ½ sec. 14, T. 49 N., R. 12 W.

(9) Boone County, Mo.: 6½ miles northwest of Columbia, 1 mile west of Hinton; lower portion of Cherokee formation exposed in small valley just west of strip coal mine. NE. ¼ sec. 10, T. 49 N., R. 13 W.

Tebo coal and associated shales exposed in south bank of small stream along west side of U. S. highway No. 63, one-half mile south of Hinton. NE. ¼ sec. 11, T. 49 N., R. 13 W.

(10) Boone County, Mo.: 11 miles north of Columbia, 4½ miles north of Hinton; lower part of Henrietta formation, and upper portion of Cherokee formation well exposed in cut along east side of U. S. highway No. 63, just south of Silver Fork Creek. NW. ¼ sec. 13, T. 50 N., R. 13 W.

(11) Boone County, Mo.: 9½ miles north of Columbia, 3¼ miles north of Hinton; Bevier coal and associated shales exposed in small valley which heads near an abandoned coal mine about 200 yards east of U. S. highway No. 63. SE. ¼ sec. 24, T. 50 N., R. 13 W.

(12) Boone County, Mo.: 4 miles southeast of Columbia; lower portion of Cherokee formation exposed in a series of outcrops along Little Bonne Femme (Gans) Creek between the southeast corner of sec. 23 (just south of Harg) and the north center of sec. 34, T. 48 N., R. 12 W.

(13) Callaway County, Mo.: 1¼ miles east of Millersburg; Cherokee formation well exposed along the west bank of Miller's Creek, about 200 yards upstream from wooden bridge on old Columbia-Fulton gravel road. E. ½ sec. 6, T. 47 N., R. 10 W.

(14) Boone County, Mo.: 1½ miles east of Columbia; Pennsylvanian fill in Mississippian limestone (Burlington formation), exposed along south bank of Hinkson Creek about 100 yards upstream from U. S. highway No. 40. SW. ¼ sec. 5, T. 48 N., R .12 W.

(15) Henry County, Mo.: 4 miles west of Windsor; Bevier (?) coal exposed in strip mine operated (1934) by Windsor Coal Company. SW. ¼ sec. 9, T. 43 N., R. 24 W.

(16) Boone County, Mo.: 2½ miles east of Harrisburg; lower portion of Cherokee formation exposed in strip coal mine and along nearby stream. SW. ¼ sec. 7, and NW. ¼ sec. 18, T. 50 N., R. 13 W.

(17) Saline County, Mo.: 1½ miles northeast of Emma; lower portion of Cherokee formation exposed along south bank of Davis Creek, just upstream from old steel bridge. *Sigillaria* remains abundant in massive sandstone member.

(18) St. Louis County, Mo.: one-half mile west of Lackland station on the C.R.I. and P. Railway, 1 mile northwest of Stratman. Lower part of Henrietta formation exposed along west side of State highway No. 77, just south of C.R.I. and P. Railway underpass. N. ½ sec. 36, T. 46 N., R. 5 E.

(19) Callaway County, Mo.: 4 miles southwest of Fulton, one-fourth of a mile northwest of Oak Grove School; lower part of Henrietta formation and upper part of Cherokee formation exposed along the east bank of Middle River and tributaries from the east. NW. ¼ sec. 12, T. 46 N., R. 10 W.

(20) Callaway County, Mo.: one-fourth mile south of Fulton; lower part of Henrietta formation and upper part of Cherokee formation exposed in cut along both sides of State highway No. 54. NE. ¼ sec. 20, T. 47 N., R. 9 W.

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ADOLESCENT DEVELOPMENT OF DITOMOPYGE[1]

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ABSTRACT

Ditomopyge was established on immature pygidia possessing characters not present in mature individuals. A considerable series of specimens from Indiana proves that these tiny spined pygidia are parts of the young of trilobites belonging to the *Griffithides scitulus* series.

Ditomopyge is redefined on the basis of its mature development and *Cyphinium* Weber is shown to be a synonym. The ontogeny of this genus is described.

The trilobite genus *Ditomopyge* was described by Newell (1) on the basis of two tiny pygidia that are characterized by a pair of slightly divergent spines produced posteriorly from the pygidial flange. These specimens were washed from shale occurring in the middle of the Plattsburg limestone of Franklin County, Kansas. Additional material subsequently washed from the shale at the type locality by Newell contained other fragmentary trilobite remains consisting of larger pygidia, five of which possess more or less inconspicuous posterior spines, a nice series of variously sized free cheeks, three incomplete cranidia and numerous fragmentary thoracic segments. (All of these specimens have been kindly lent to me for study.)

A much more complete series of comparable specimens was obtained by me nearly ten years ago from a linestone occurring near the base of the Pennsylvanian system in Warren County, Indiana. This bed is a hard, black, fine-grained stratum containing an abundant and diversified marine fauna. Locally many of the smaller specimens have been silicified, and abundant, beautifully preserved fossils may be obtained from the residues derived from this limestone by treatment with dilute hydrochloric acid. The trilobite specimens consist of a considerable series of pygidia ranging in size from less than 1 to more than 5 mm. in length, abundant free cheeks from 1.5 to 8.5 mm. long, a few imperfect cranidia and abundant, fragmental thoracic segments. This limestone has also yielded, by more conventional collecting methods, a number of more or less complete specimens that attain a maximum length of about 18 mm.

The seventeen smallest pygidia from the Indiana locality possess posterior spines similar to those of Newell's described specimens and when these are arranged in a series according to size, followed by a similarly arranged series of the larger spineless pygidia, complete gradation is apparent. The smallest pygidium discovered seems to represent an early post-larval stage in the develop-

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ment of this trilobite. At the other extreme, the specimens lead up to mature, fully grown, identifiable individuals. So far as I am aware, no similar developmental series has ever been observed for any other Carboniferous trilobite.

The collection of the Illinois State Geological Survey also contains a small spined pygidium from Sangamon County, Illinois, which occurs on the same fragment of rock as a fully grown, nearly complete trilobite, and a tiny, enrolled somewhat crushed specimen with spined pygidium from Palo Pinto County, Texas.

IDENTIFICATION OF SPECIMENS

Newell's specimens are the syntypes of his new species *Ditomopyge lansingensis*. The mature form of this species is not and perhaps never will be certainly known, although I have applied this name to certain mature specimens collected from an approximately equivalent horizon in Illinois.

I have identified the fully grown Indiana specimens, to which the smaller pygidia unmistakably lead, as *Griffithides olsoni* recently described by Williams from Boone County, Missouri (5). This species belongs to the same group of trilobites as that described many years ago by Meek and Worthen as *Phillipsia* (*Griffiithides*) *scitula*. Trilobites of this group are extensively present in the Pennsylvanian beds of the United States, ranging from strata of Morrow age into the Lower Permian. For the last 35 years or more they have been referred almost exclusively to the genus *Griffithides* Portlock (2). On the basis of the study of nearly 1,000 specimens from the Carboniferous beds of the Donetz Basin of Russia, Weber, in 1933, separated this group of Pennsylvanian trilobites from *Griffithides*, proposed for it the new subgeneric name *Cyphinium*, and selected *Griffithides scitulus* as the subgenotype (3).

My recently completed, systematic study of American Carboniferous trilobites (4) has led me to sharply restrict Portlock's genera *Griffithides* and *Phillipsia*, to which most American Carboniferous forms have always been referred, and to arrange the rejected species into a number of other generic groups. One of these appears to be identical to that to which Weber applied the name *Cyphinium*. The series of Indiana specimens briefly described above, however, shows conclusively that the trilobites of this genus passed through an adolescent stage in which the pygidium terminated in two posterior spines similar to those characteristic of *Ditomopyge* as described by Newell. Moreover, the series of free cheeks and larger pygidia associated with the syntypes of *D. lansingensis* are good evidence that this species is a member of the generic group under consideration rather than the only other generic group known in this part of the Pennsylvanian system, of which "*Phillipsia*" *major* Shumard is a typical example. The close relationship, therefore, existing between *G. olsoni*, of which we know the development beyond an early post-larval stage, *G. scitulus*, the subgenotype

of *Cyphinium*, and *D. lansingensis*, the genotype of *Ditomopyge*, clearly indicates the synonymity of these two recently proposed names, of which *Cyphinium* must be rejected because *Ditomopyge* possesses two years priority.

The tiny spined pygidium from Illinois is closely associated with a specimen identified as Girty's species *G. parvulus*, but a specimen of "*Phillipsia*" *sangamonensis* Meek and Worthen is also present in the collection obtained at this locality. The small pygidium is referred to the former species chiefly because of its similarity to adolescent specimens known to be congeneric.

Representative specimens from each of the three above mentioned localities are figured on the accompanying plates and the exact locations and horizons are noted in the explanations. The Texas specimen, which is not illustrated, was obtained from the Keechi Creek shale 25 feet below the Palo Pinto limestone, 7.4 miles by road northwest of the Crazy Hotel in Mineral Wells, at F. B. Plummer's locality M.W. 5. The identification of this specimen is doubtful, but judging by its stratigraphic position it might possibly be referred to either *D. olsoni* or *D. parvula*.

Genus DITOMOPYGE Newell, emend. Weller

Because the mature characters of *Ditomopyge*, which was originally based on adolescent specimens possessing characters not preserved in the adult, are now known a revised diagnosis of this genus is required as follows:

Cephalon semi-elliptical, broader than long, evenly rounded in front. Genal spines extending from second to seventh thoracic segments, length fairly constant within individual species. Glabella large, longer than wide, reaching or slightly overhanging anterior margin, more or less expanded in front, contracted between eyes. Basal lobes large, prominent, subtriangular. Basal furrows slightly curved to nearly straight. Anterior glabellar furrows faint to absent. Preoccipital lobe present, formed by nearly straight, transverse furrow joining basal furrows between eyes. Eyes large, about half as long as glabella. Fixed cheeks narrow.

Thorax with nine segments.

Pygidium strongly segmented, semi-elliptical, broader than long, generally evenly rounded behind, about equal in size to cephalon. Axis strongly elevated; sides flattened, steeply sloping; top generally flattened; composed of 10 to 15 recognizable segments. Pleural lobes composed of 6 to 8 recognizable segments, commonly rather abruptly geniculated at about mid-width. Flange distinct, sharply separated from and generally less steeply sloping than outer parts of segmented pleural lobes, without undulations continuing pleural segments except anteriorly when these are more or less faintly developed.

Ornamentation consists of variously sized granules most prominent on posterior and lateral portions of

glabella and neck-ring and generally larger and more uniform granules arranged in series along posterior edges of neck-ring and axial segments and pleura adjacent to points of geniculation.

The genotype of *Ditomopyge* is *D. lansingensis* Newell, 1931, and *Cyphinium* is a synonym (genotype *P. scitula* Meek and Worthen, 1865).

PYGIDIAL ONTOGENY

The smallest pygidium of *D. olsoni* (text figs. 4*a–c*) is completely formed, possesses well differentiated axis, segmented pleural lobes, and flange, and obviously represents an early post-larval stage in the development of this species. Its ratio of breadth to length is not known because the anterior margin of this specimen appears to have been broken away. The posterior spines are comparatively large and prominent and are spaced nearly as widely as the size of the pygidium will permit. The flange is quite narrow anteriorly but widens greatly behind and is arched strongly upward and elevated posteriorly.

During adolescence, which may be defined as terminating with the disappearance of the posterior spines, the size of the individual increased about four-fold. Maturity was reached when the pygidium attained a width of about 3 mm. but growth continued and the trilobite subsequently more than doubled in size. The posterior spines throughout adolescence remain practically uniform in size and spacing in spite of growth of the pygidium and, therefore, are much less conspicuous in the later stages (text figs. 5*a*, 6*a*, 7*a*). Likewise the posterior spine-bearing portion of the flange does not increase in width, but the flange along the lateral borders widens gradually until a nearly uniform width is attained. As the relative size of posterior spines and width of flange changed with the growth of the individual, the posterior pygidial arching and elevation decreased and in this species disappeared with the attainment of maturity.

The lobes of the pygidium are sharply demarked and their relative sizes remain fairly constant from early adolescence to maturity. The shape and relative proportions of the segmented parts as a whole, however, changed rapidly during the first half of the adolescent stage and more slowly later. This portion of the smallest pygidium is very blunt be-

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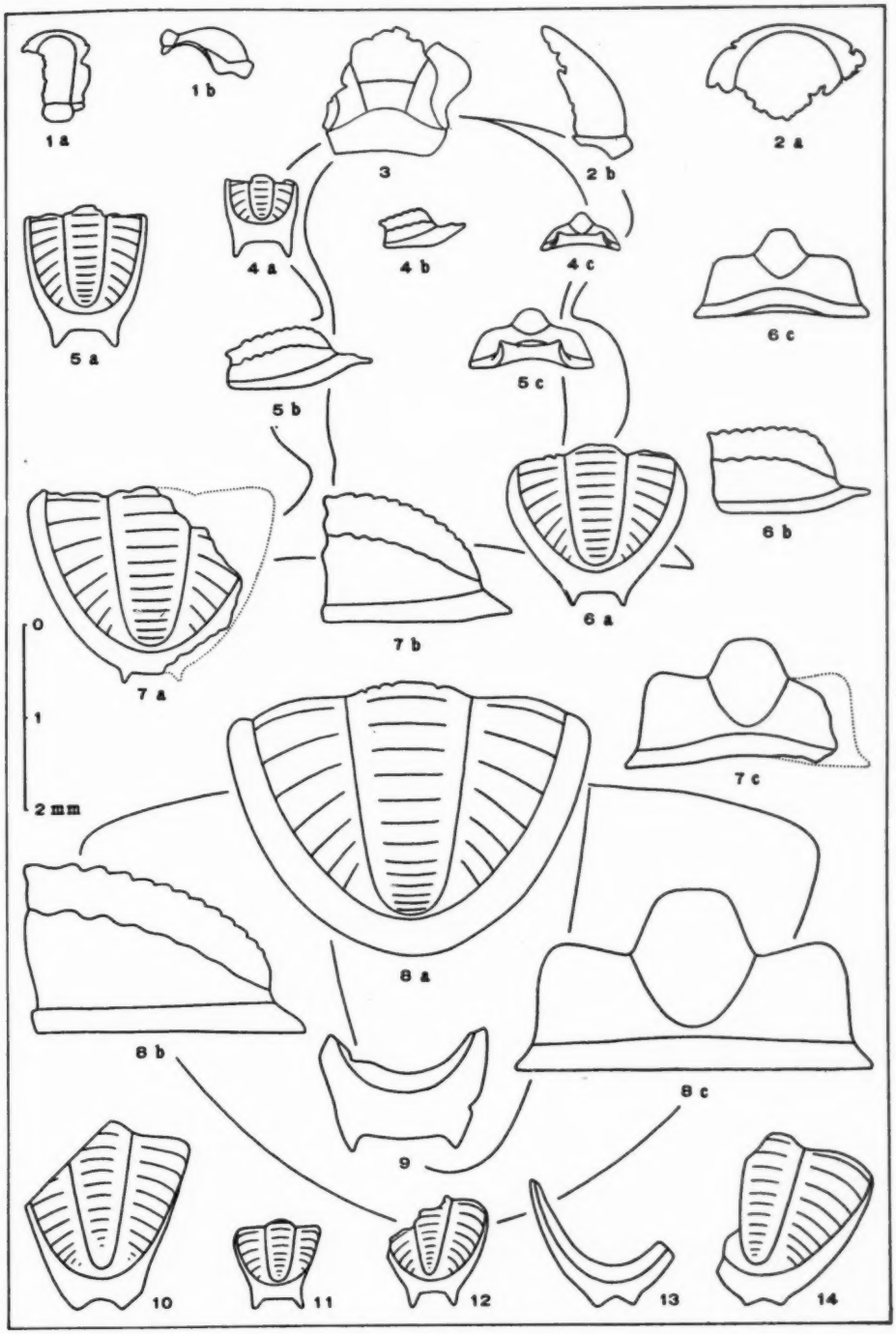
All figures enlarged 12½ times

TEXT FIGS. 1*a*–8*c*—*Ditomopyge olsoni* (Williams), Seville (?) limestone, NE. ¼ NW. ¼ sec. 35, T. 21 N., R. 9 W., Warren County, Indiana. 1*a*–3, Three fragmentary cranidia. 4*a*–7*c*, Adolescent pygidia. 8*a–c*, Smallest mature pygidium.

9—*Sevillia?* sp. Same horizon and locality. Fragment of a pygidium.

10—*Ditomopyge parvula* (Girty), Sparland limestone, SE. ¼ NE. ¼ sec. 11, T. 16 N., R. 6 W., Sangamon County, Illinois.

11–14—*Ditomopyge lansingensis* Newell, Plattsburg limestone, middle north line, sec. 36, T. 16 S., R. 21 E., Franklin County, Kansas. 11–12, Syntypes. 13–14, Topotypes. Fig. 14 was drawn with the specimen in a slightly inclined position. Superimposed on this page are the outlines of a fully grown cranidium and pygidium of *D. olsoni* drawn to the same scale as the other figures.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14

hind and is sub-parallel laterally. In the next larger specimen (text fig. 5*a*) it is more rounded behind but still subquadrate in outline with length and breadth almost exactly equal. By the time the next stage illustrated has been attained (text fig. 6*a*) the segmented portion of the pygidium has become semi-elliptical, with a ratio of breadth to length of nearly 1.3. Thereafter this shape is maintained but a slight amount of further broadening occurs. Throughout the entire adolescent development of this species the strength of the pygidial lobation gradually increases as a result of the progressive deepening of the axial furrows. Although the number of discernible pygidial segments varies somewhat among the different individuals, they fall within or close to the limits determined on the basis of fully grown specimens and there appears to be no relationship between number of segments and size of pygidium within this series.

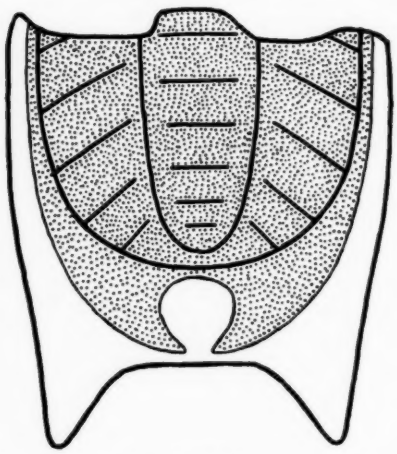

FIG. 15—Pygidium of *Ditomopyge lansingensis*. Same specimen illustrated in figures 4 *a–c*. ×60.

Some of the small pygidia possess a more or less inconspicuous notch or indentation of the flange between the spines as described by Newell but others do not. This feature, therefore, is not constant and perhaps is only accidental. Better specimens than those studied by Newell show that the "small subcircular area" on the flange immediately behind the termination of the axial lobe, interpreted by him as a calcite filled "cyclindrical space open above and below and on the posterior side between (the) two projecting points of the flange," is probably quite different in its nature. Several of the tiny pygidia are composed of light-colored very finely crystalline and more or less translucent material which contrasts strongly with the darker, argillaceous or siliceous, opaque matrix. When illuminated properly, the shells of such specimens appear lightest where thickest and the outer edge of the thin layer of matrix occupying the fold between the upper surface of the flange and its recurved doublure below is more or less sharply defined. In the smallest specimen from the Indiana locality this fold is apparently interrupted immediately behind the axis where the doublure is unseparated from the main upper part of the flange throughout a comparatively large subcircular area. Larger pygidia whose shells contrast less strongly with the matrix suggest that with growth of the individual the two points of the fold, which almost meet

posteriorly, draw apart and the fold recedes between them until an even outline has been attained.

The series of pygidia of *D. lansingensis* is not nearly as complete as that of *D. olsoni* but illustrates a similar development. The two smallest specimens (text figs. 11, 12) possess spines comparable in size, shape, and spacing to those described above and are also strongly arched and elevated posteriorly. In later adolescent stages, however, the spines become progressively broader without increasing in length and appear to gradually lose themselves in the posterior curvature of the flange (text figs. 13, 14). The spines also disappeared at an earlier stage of development, because pygidia only slightly larger than that illustrated in text figure 14 are entirely spineless before the widening of the flange anteriorly had been completed. Although the posterior arching of the pygidium, so characteristic of the earlier adolescent stages, disappeared with the obsolescence of the spines in *D. olsoni* and *D. lansingensis*, it persisted conspicuously in later stages of *D. scitula* and is faintly preserved in some fully grown individuals of this species.

The axial furrows of species of *Ditomopyge* younger than *D. olsoni* do not show progressive deepening to the same extent as do those of that species. In their mature and fully grown development the pleural lobes of their pygidia are not so sharply geniculated.

The single small pygidium referred to *D. parvula* (text fig. 10) possesses much broadened posterior spines, comparable to those of *D. lansingensis*.

A single fragmentary pygidium (text fig. 9) found associated with *D. olsoni* at the Indiana locality possesses posterior spines much more widely spaced than any of the others. Because of the constancy of the spacing of the spines in variously sized pygidia of three species of *Ditomopyge* it appears probable that this specimen does not belong to that genus. Consequently, I have referred it very tentatively to the only other genus, as yet undescribed, which I have found to be locally abundant in this part of the Pennsylvanian system.

CRANIDIAL ONTOGENY

Material upon which conclusions regarding the cranidial development of *Ditomopyge* may be based is very scanty and by no means satisfactory. Adolescent cranidia were apparently very delicate and much more susceptible to injury or complete destruction during the process of fossilization than were free cheeks or pygidia which were protected to some extent, at least, by their doubled margins.

The smallest cranidium of *D. olsoni* that has been observed is 1 mm. long and complete except for the left fixed cheek and the posterolateral occipital projections. The glabella is nearly twice as long as wide and slightly expanded anteriorly. Its exact shape, however, is a little doubtful because of the presence in the right axial furrow of some

siliceous material which cannot be removed without danger of destroying the specimen. The glabella does not reach to the anterior margin but is bounded before by a gently sloping rim above which it rises steeply. The occipital furrow is well marked and open, but the glabella is entirely unfurrowed and there is not even a suggestion of basal or preoccipital lobes. The fixed cheek is relatively very wide and the palpebral lobe is long for trilobites of this type.

Although the absence of a preoccipital lobe accords with the theoretical ancestry of this genus, the absence of basal lobes on this specimen is a surprising and totally unanticipated feature. Studies of the larval forms of several trilobite genera have shown that the glabella, at its earliest known stages, is clearly segmented and that this primitive segmentation gradually developed into the mature lobation characteristic of the various forms. Is it possible that the basal lobes of *Ditomopyge*, and consequently of other related genera, are morphologically different from the basal lobes of other older trilobites whose complete ontogenies have been worked out? Carboniferous and Permian trilobites are known from Europe and Asia which possess no basal lobes, but I have regarded them as representatives of an advanced rather than a primitive branch of the Proetidae. Unless this small cranidium is abnormal, however, the glabellar lobation typical of *Ditomopyge* developed during the adolescent stage as is shown by the fragmentary specimen illustrated by text figure 3.

The marginal rim anterior to the glabella is a primitive character in this group of trilobites. In *Ditomopyge* it becomes steeper and narrower as the individual develops (text figs. 2*a–b*) and, probably in early maturity, becomes vertical or overhanging and is separated from the glabella, which then forms the anterior extremity of the cephalon, by only a faint furrow. Small cranidia of a common Chester species of a related genus possess even more prominent marginal rims which nearly or entirely disappear as full growth is approached. A prominent marginal rim, however, is characteristic of other proetid genera and persisted even into Permian time.

The relatively long and narrow glabella possessed by the smallest cranidium is quite different from that present in fully grown individuals in which it is only about one-third again as long as broad. The wide fixed cheeks of the smallest specimen, however, compensate for this difference and a reconstruction of the entire cephalon indicates that its proportions at this early stage are as a

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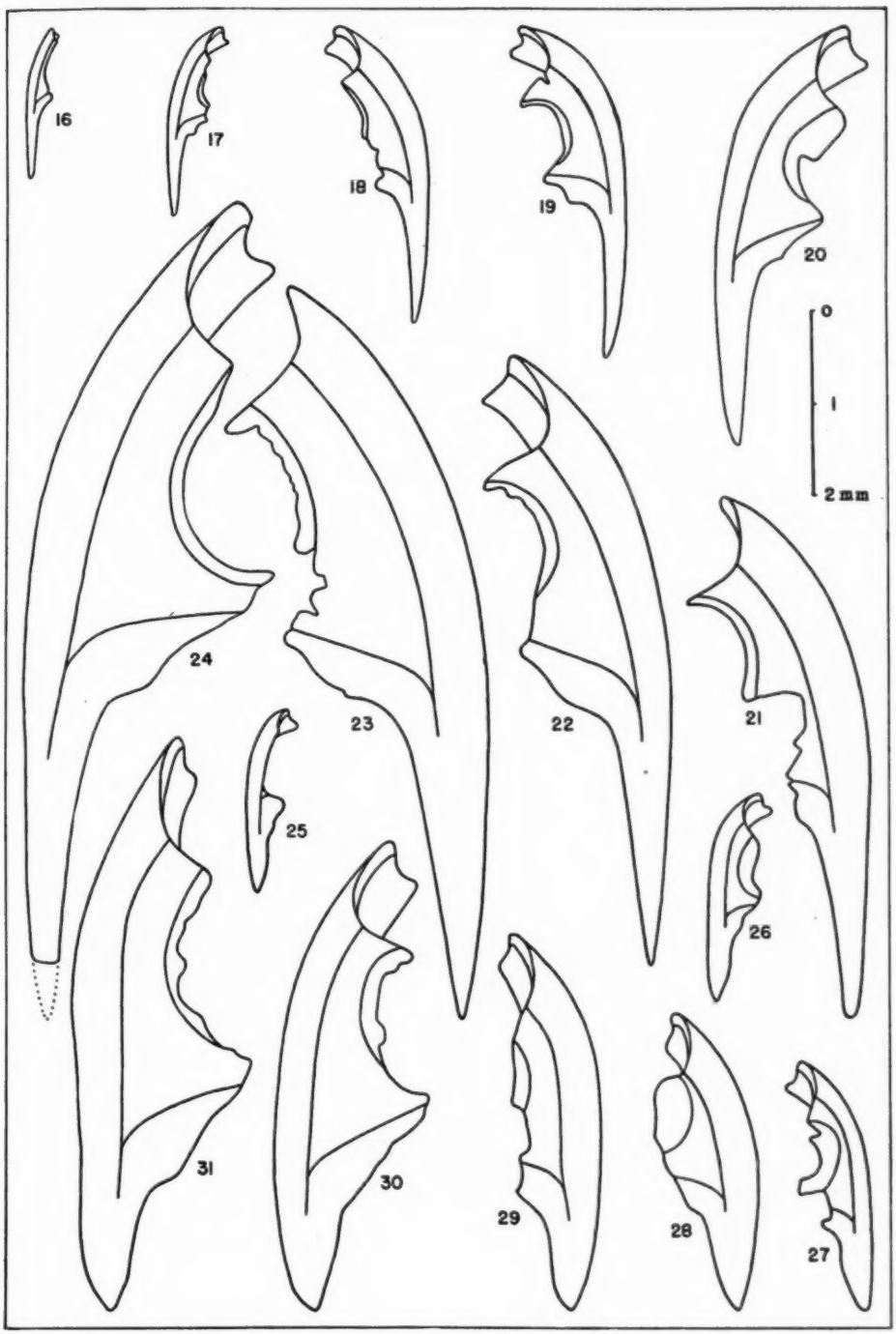
All figures enlarged 12½ times.

TEXT FIGS. 16–24—*Ditomopyge olsoni* (Williams), Seville(?) limestone, NE. ¼ NW. ¼ sec. 35, T. 21 N., R. 9 W., Warren County, Indiana. Free cheeks.

25–31—*Ditomopyge lansingensis* Newell, Plattsburg limestone, middle north line sec. 36, T. 16 S., R. 21 E., Franklin County, Kansas. Free cheeks; topotypes. The eyes in figures 27 and 28 have been somewhat displaced by crushing.


16
17
18
19
20
0
1
2 mm
24
23
22
21
25
26
31
30
29
28
27

whole similar to those of fully grown individuals. The eyes, however, appear to be relatively somewhat longer than in adult specimens.

No series of cranidia of any other species of *Ditomopyge* has been obtained nor are any other specimens sufficiently youthful to supplement the conclusions based on this single small cranidium of *D. olsoni*.

FREE CHEEK ONTOGENY

The only notable change that occurs in the growth of the free cheeks of *D. olsoni* and *D. lansingensis* is decrease in the relative length of the genal spines. The following table shows the proportionate lengths of these spines, measured from the tip to the junction of the cheek furrows near the genal angle, to the length of the remaining anterior portion of the free cheeks for the series of specimens illustrated by text figures 16–31.

Relative length of genal spines of *D. olsoni* and *D. lansingensis*

D. olsoni		*D. lansingensis*	
fig. 16	1.00	fig. 25	1.00
fig. 17	0.77	A	0.75
fig. 18	0.79	fig. 26	0.66
fig. 19	0.86	B	0.52
fig. 20	0.72	fig. 27	0.54
fig. 21	0.71	fig. 28	0.51
fig. 22	0.72	fig. 29	0.49
fig. 23	0.76	fig. 30	0.40
fig. 24	0.72	fig. 31	0.40

Specimens A and B in the second column are intermediate free cheeks of *D. lansingensis* that are not figured.

Both of these species appear to possess genal spines of about equal length in early adolescence but in neither does increase in length of spine keep pace with the later growth of the individual. This suggests that these species were derived from ancestral forms possessing relatively longer genal spines. Substantiation of this conclusion is furnished by the fact that the spines of *D. lansingensis*, the younger of the two species, decrease in proportionate length much more rapidly than those of *D. olsoni*. Also, the study of mature specimens of several species of *Ditomopyge* characteristic of different horizons clearly shows that there was a general gradual decrease in the length of genal spine from the lowest Pennsylvanian species, of Morrow age, in which they extend to about the seventh thoracic segment, to a Lower Permian species in which they do not reach beyond the second.

CONCLUSIONS

Although the smallest known specimens of *Ditomopyge* are comparable in size to the known larval stages of several other trilobite genera, these specimens consist of parts of well formed cephala and pygidia that have definitely passed beyond the larval stage of development. In *Proetus parviusculus* Hall from the Upper Ordovician, which is probably the nearest relative of *Ditomopyge* whose larvae have been discovered, the cephalon was at least 0.7 mm. long before the larval stage was passed, in spite of the fact that fully grown individuals attain a total length of less than 1 cm. Because of the tiny size of this species, which is considerably smaller than any known in the genus *Ditomopyge*, it does not

seem likely that its eggs were larger than those of the genus under consideration, thus accounting for the more rapid attainment of adolescence in the latter. It is more probable that accelerated development resulted in the hatching of *Ditomopyge* larvae in a somewhat more advanced state.

Although the larval forms of *Ditomopyge* are unknown, the adolescent specimens, in accordance with the law of recapitulation, furnish evidence regarding the ancestry of this genus. On this basis the forerunner of *Ditomopyge* appears to have been characterized by a long, rather slender glabella without basal or preoccipital lobes and bounded in front by a flattened marginal rim, large elongated eyes, long genal spines, and a pygidium strongly arched upward and elevated behind and terminated by a pair of caudal spines. No such trilobite is known.

The flattened marginal rim anterior to the glabella is characteristic of several genera of the Proetidae and other evidence substantiates the conclusion that *Ditomopyge* was derived from a form possessing such a structure. The absence of basal lobes suggests comparison with the other proetid genera *Haploconus* Raymond from the Ordovician and *Neoproetus* Tesch from the Permian. The posterior arching of the pygidium is somewhat similar to that of *Calymene* and the spines are much like those possessed by certain species of *Odontocephalus*, as Newell has already pointed out, but both of these latter genera are members of the Proparia and, therefore, such comparisons are not significant. Conclusions based upon the stratigraphic sequence of Carboniferous trilobite types suggests that *Ditomopyge* was derived from a form with smaller eyes and a corrugated pygidial flange whose undulations continue the pleural segmentation nearly to the margin. The ontogeny, however, appears to contradict the former conclusion and none of the immature pygidia possess corrugated flanges, but this character may have been lost at a stage younger than any that is now known.

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FRESH-WATER INVERTEBRATES FROM THE MORRISON (JURASSIC?) OF WYOMING

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ABSTRACT

A fresh-water faunule from the Morrison formation is described and three new genera are established: *Vetulonaia* in the Pelecypoda, *Pentagoniostoma* in the Gastropoda, and *Morrisonia* in the Ostracoda. Morrison invertebrate faunas in general are discussed.

During the summer of 1933, E. B. Branson and the writer obtained a large collection of invertebrates from a fresh-water horizon in the Morrison formation three miles south of Mayoworth, Wyoming, in the eastern foothills of the Bighorn Mountains. The fossiliferous bed is a lens of greenish argillaceous sand about a foot thick and 200 feet in length along the outcrop. The bed lies near the middle of the Morrison and a few feet above a dinosaur-bearing member. Numerous specimens of Unios lie weathered out on the surface and the sands yield many specimens of small gastropods, ostracodes, fragments of fish bones, and a *Chara*-like spore case. The occurrence of Morrison invertebrates in sand is unusual, as all previous collections have been found in limestones.

The earliest mention of Morrison invertebrates is by Meek and Hayden, who described a small faunule from the Black Hills (4). The species found there are *Unio nucalis*, *Planorbis veternus*, *Valvata scabrida* and *Viviparus gilli*. *Neritina nebraskensis* and *Lioplacodes veternus* were described from a locality near the head of Wind River in Wyoming. The Morrison age of the last two species has been questioned by later writers. All of the above species, with the exception of *Viviparus gilli*, were described without illustrations in an earlier paper by Meek and Hayden (3).

C. A. White reviewed Meek and Hayden's species in 1883 (9), and in 1886 described a fine collection of fresh-water invertebrates from the *Atlantosaurus* beds near Cañon City, Colorado. The species comprise *Unio stewardi* White (originally described from the Uinta Mountains from very fragmentary types, U. S. Nat. Mus., 8849), *Planorbis veternus*? Meek and Hayden, *Valvata scabrida*? Meek and Hayden, and the new species *Unio felchi*, *U. toxonotus*, *U. macropisthus*, *U. iridoides*, *U. lapilloides*, *Limnaea ativuncula*, *L. consortis*, *L.? accelerata*; and in the same paper he described *Vorticifex stearnsi* and identified *Unio nucalis* Meek and Hayden from the Morrison at Como, Wyoming. T. R. Jones described the ostracodes from Cañon City in the same year (1), but his paper has been ignored by Stanton, Mook, and Roth in their dis-

cussions of Morrison invertebrates.

In 1900, W. N. Logan described a small faunule from the Morrison of the Freeze-out Hills, Wyoming (2). His new species are *Unio knighti*, *U. baileyi*, *U. willistoni*, and *Valvata leei*. He identified *Planorbis veternus* Meek and Hayden from these beds, but in his paper refers to it by mistake as *Lioplacodes veternus* Meek and Hayden. Logan's new species are founded on fragmentary material and his illustrations are outline drawings. The writer considers these species invalid.

In January, 1934, Robert Roth described a faunule of ostracodes, all new species, from the Morrison of

Distribution of Morrison Fresh-water Invertebrates

	Mayoworth	Cañon City	Black Hills	Freeze-out Hills	SW. Wyoming	Como	Tensleep	Head Wind River
Unio stewardi White	—	×	—	—	—	—	—	—
Unio felchi White	—	×	—	—	—	—	—	—
Unio toxonotus White	—	×	—	—	—	—	—	—
Unio macropisthus White	—	×	—	—	—	—	—	—
Unio iridoides White	—	×	—	—	—	—	—	—
Unio lapilloides White	—	×	—	—	—	?	—	—
Unio knighti Logan	?	—	—	×	—	—	—	—
Unio baileyi Logan	?	—	—	×	—	—	—	—
Unio willistoni Logan	?	—	—	×	—	—	—	—
Vetulonaia whitei Branson, n. sp.	×	—	—	—	—	—	—	—
Vetulonaia mayoworthensis Branson, n. sp.	×	—	—	—	—	—	—	—
Vetulonaia? nucalis Meek and Hayden	×	—	*	—	—	?	—	—
Planorbis veternus Meek and Hayden	×	?	*	×	—	—	—	—
Limnaea ativuncula White	—	×	—	—	—	—	—	—
Limnaea consortis White	—	×	—	—	—	—	—	—
Limnaea? accelerata White	—	×	—	—	—	—	—	—
Neritina nebraskensis Meek and Hayden	—	—	—	—	—	—	×	×
Valvata scabrida Meek and Hayden	—	?	*	—	—	—	—	—
Valvata leei Logan	—	—	—	×	—	—	—	—
Valvata? jurassica Branson, n. sp.	×	—	—	—	—	—	—	—
Vorticifex stearnsi White	—	—	—	—	—	×	—	—
Pentagoniostoma jurassicum Branson, n. sp.	×	—	—	—	—	—	—	—
Pentagoniostoma altispiratum Branson, n. sp.	×	—	—	—	—	—	—	—
Lioplacodes veternus Meek and Hayden	?	—	—	—	—	—	—	—
Viviparus gilli Meek and Hayden	×	—	*	—	—	—	—	×
Jonesina minnekahtensis Roth	—	—	×	—	—	—	—	—
Jonesina pahasapensis Roth	—	—	×	—	—	—	—	—
Metacypris forbesi Jones	—	×	—	—	—	—	—	—
Metacypris bradyi Jones	—	×	—	—	—	—	—	—
Metacypris whitei Jones	—	×	—	—	—	—	—	—
Darwinula leguminella Forbes	×	×	—	—	—	—	—	—
Paracypris simplus Roth	—	—	×	—	—	—	—	—
Paracypris acuminatus Roth	—	—	×	—	—	—	—	—
Bairdiocypris morrisonensis Roth	—	—	×	—	—	—	—	—
Bairdiocypris trapezoidalis Roth	—	—	×	—	—	—	—	—
Cypris purbeckensis Forbes	—	—	*	—	—	—	—	—
Cytherideis marshi Jones	—	—	*	—	—	—	—	—
Pseudocypridina piedmonti Roth	—	—	×	—	—	—	—	—
Cytheridea? atlantosaurica Jones	—	—	*	—	—	—	—	—
Morrisonia wyomingensis Branson, n. sp.	×	—	—	—	—	—	—	—

the Black Hills (6). This paper is discussed under Ostracoda in the section on systematic paleontology of this paper.

The table on page 515 lists the species and localities of Morrison fresh-water invertebrates. In the record for the Black Hills, species listed by Meek and Hayden are indicated by an asterisk (*), the remainder being reported by Roth.

The above table demonstrates clearly that Morrison fresh-water faunas are similar in scattered localities, but are essentially local. The table is confusing because of a number of invalid and probably identical species under different names. This is particularly true of the Unios, of which only *U. nucalis*, *Vetulonaia whitei*, and *V. mayoworthensis* have more than shape to distinguish them. Three of the ostracodes from Colorado were identified by Jones as Purbeck species, and two or three of Roth's species appear to be conspecific with species identified by Jones.

Correlation on the basis of the fresh-water invertebrates is not possible. The species do not correspond to those of other formations and the genera are long-lived. T. W. Stanton has discussed at length correlation on the basis of the invertebrates (8), and we have nothing to add to his conclusions. C. C. Mook has published an excellent resumé of Morrison correlation in which all phases are discussed (5).

The types of new species described in the present paper are deposited in the collections of the University of Missouri.

SYSTEMATIC PALEONTOLOGY

Subphylum PELECYPODA

Family UNIONIDAE

Unionidae in considerable abundance are known from several formations in the North American Mesozoic,—the Dockum, Chinle, and Chugwater in the Triassic, the Morrison in the Jurassic, and the Potomac, Kootenai, Bear River, Belly River, Judith River and Laramie in the Cretaceous. Most of these forms are related to modern genera, but nearly all are referred to *Unio* or *Anodonta*. L. S. Russell has attempted to bring the classification of Canadian fossil Unionidae up to date to correspond with present taxonomy of modern forms (7). Unfortunately, the dentition and umbonal ornamentation, which are the chief bases of classification when the gills are unknown, are not known in many Mesozoic forms.

Of the ten previously described species of Morrison Unionidae, only *Unio nucalis* Meek and Hayden is represented by specimens in which the dentition and the ornamentation is preserved. The syntypes of *U. stewardi* White are worn shell fragments (U. S. Nat. Mus., 8849). Logan's three species from the Freeze-out Hills are fragmentary and are inadequately figured. An examination of White's types from Colorado showed that the syntypes of *U. felchi* are good specimens of both valves, but without dentition or ornamentation (U. S. Nat. Mus., 20048), the syntypes of *U. iridoides* are poorly preserved shells (U. S. Nat. Mus., 20051), the holotype of *U. toxonotus* and the syntypes of *U. macropisthus* and *U. lapilloides* are internal molds (U. S. Nat. Mus., 20049, 20050, 20052). If these species are to be established the descriptions must be augmented by topotype material.

The specimens in my collection bear radial undulations similar to those of *U. (Medionidus ?) senectus* White and bear concentric wrinkles on the umbones like those of *U. nucalis* Meek and Hayden.

Genus VETULONAIA C. C. Branson, n. gen.

Unionidae with nearly terminal beaks, left valve with two lateral teeth, cuneiform pseudocardinal tooth above triangular socket; right valve with single lateral tooth, cuneiform pseudocardinal tooth below triangular socket; umbonal region marked by concentric wrinkles, ventral area posterior to the beaks marked by radial undulations.

Dr. L. S. Russell, who has examined photographs of the types, writes:

> There is quite a resemblance to certain species of *Pleurobema* Rafinesque, as now defined. This appears in the rather heavy shell, the triangular outline, and the terminal beaks. I am not certain from the photographs whether there are two pseudocardinal teeth on the right valve, or only one. The members of *Pleurobema* are supposed to have two on each valve. The beak ornamentation in this genus consists of a few coarse, irregular plications. Such might be derived by degeneration from the pattern shown in your drawing. However, I hardly think the evidence is strong enough to justify inclusion of the Morrison fossils in *Pleurobema*. I am afraid that you will either have to stick to *Unio*, or else make a new genus.

It is probable that *Unio nucalis* Meek and Hayden, and Logan's several species belong in this genus. The ornamentation is easily destroyed, for of my two hundred selected specimens about fifty show the wrinkles and only three show the undulations.

Etymology, Latin *vetulus*, advanced in life; Nais, a water-nymph. Genotype, *V. whitei* C. C. Branson, n. sp.

VETULONAIA WHITEI C. C. Branson, n. sp.
Plate 56, figures 1–5, 8–10, 12, 13, 15, 19

Shell subovate to nearly rhomboidal, length greater than height: beaks almost terminal, moderately elevated, curved inward and forward; anterior margin short, bulged beneath the beaks at point where greatest length is measured, inclined backward below the bulge to the long smooth curve of the ventral margin; posterior margin short, rounded on a short radius; dorsal margin nearly straight to posterior third, which slopes downward at about a thirty degree angle to the posterior corner. A slight sinus extends from the anterior portion of the umbo to the anterior margin just below the bulge. The posterior slope bears a broad shallow sinus from the umbo to the posterior corner of the ventral margin. The umbo is distinctly set off from the rest of the shell and is ornamented by nine to eleven rough discontinuous wrinkles concentric about the beak, but with a slight angulation at the posterior shoulder. The wrinkles do not extend in front of the beak and become obsolete behind the beaks near the hinge area. A set of about twenty radial undulations occupies the ventral portion of the posterior side of the umbo and the adjacent part of the posterior slope and curve gently to the hinge. The radial undulations are irregular, increase by intercalation; those between the concentric wrinkles and the hinge are short; some undulations are interrupted and appear as sharp nodes where they cross the coarser growth lines near their termination a third of the distance from the beaks to the posterior.

The hinge is a broad arch bearing a long linear lateral tooth on the right valve which fits into a socket between two linear teeth on the left valve. The right valve bears a nearly triangular socket beneath the beak and a strong rough tooth below and in front of the socket. The left valve has a large wedge-like tooth above and behind a small deep socket. The anterior muscle scar is oval, deep, lies near the anterior margin beneath the bulge, and has a small posterior notch and a narrow linear scar extending obliquely posterior and ventrad

and separated from the main scar by a narrow ridge. The posterior muscle scar is circular, shallow, larger than the anterior scar, and lies near the hinge at the beginning of the abrupt posterior slope of the dorsal margin.

The two hundred specimens in the collection show considerable variation in size, obliquity of the shell, height of the beaks, position of the beaks from nearly terminal to well behind the anterior margin, and in strength of the dentition, but the variations can be shown to belong in a continuous series, and since they have no stratigraphic significance they do not deserve to be distinguished as separate species. The holotype is 47 mm. long, 27 mm. high, and 25 mm. wide. Specimens vary in length from 17 mm. to 77 mm.

Remarks.—Nearly all Morrison species of Unionidae are known from shape alone and many of these can not be distinguished from some varieties of *Vetulonaia whitei*. It is possible that Logan's species *Unio baileyi*, *U. knighti*, and *U. willistoni* are all conspecific with my species. *U.* (*Medionidus*?) *senectus* White of the Cretaceous is similar in bearing undulations behind the umbones. A specimen in the National Museum (U. S. Nat. Mus., 31071) appears to come from the same locality as *V. whitei* and belongs to that species. The species is named in honor of C. A. White.

VETULONAIA? NUCALIS (Meek and Hayden)
Plate 56, figure 6

A few specimens from Mayoworth are elliptical in outline, have low beaks some distance behind the front margin, and bear concentric wrinkles on the umbo These are referred to Meek and Hayden's species, although they could be considered end forms in one line of variation in *V. whitei*.

VETULONAIA MAYOWORTHENSIS
C. C. Branson, n. sp.
Plate 56, figures 7, 11, 14, 16–18

Shell very oblique, massive, subtrigonal; beak prominent, twisted downward and forward, the twist involving the entire anterior portion of the shell. The dorsal margin is nearly straight, the anterior margin short and irregular, the ventral margin broadly curved, the posterior margin short and abruptly rounded. A broad shallow sinus extends from the umbo to the posterior part of the ventral margin. A broad sinus extends from the anterior corner of the top of the beak to the anterior part of the ventral margin and bears an irregular low ridge in its center. A short deep sinus lies parallel to the dorsal margin in front of the beak and is separated from the hinge area by a prominent ridge. The beak is marked by eight concentric wrinkles which bend in an acute angle at the dorsal shoulder posterior to the beaks.

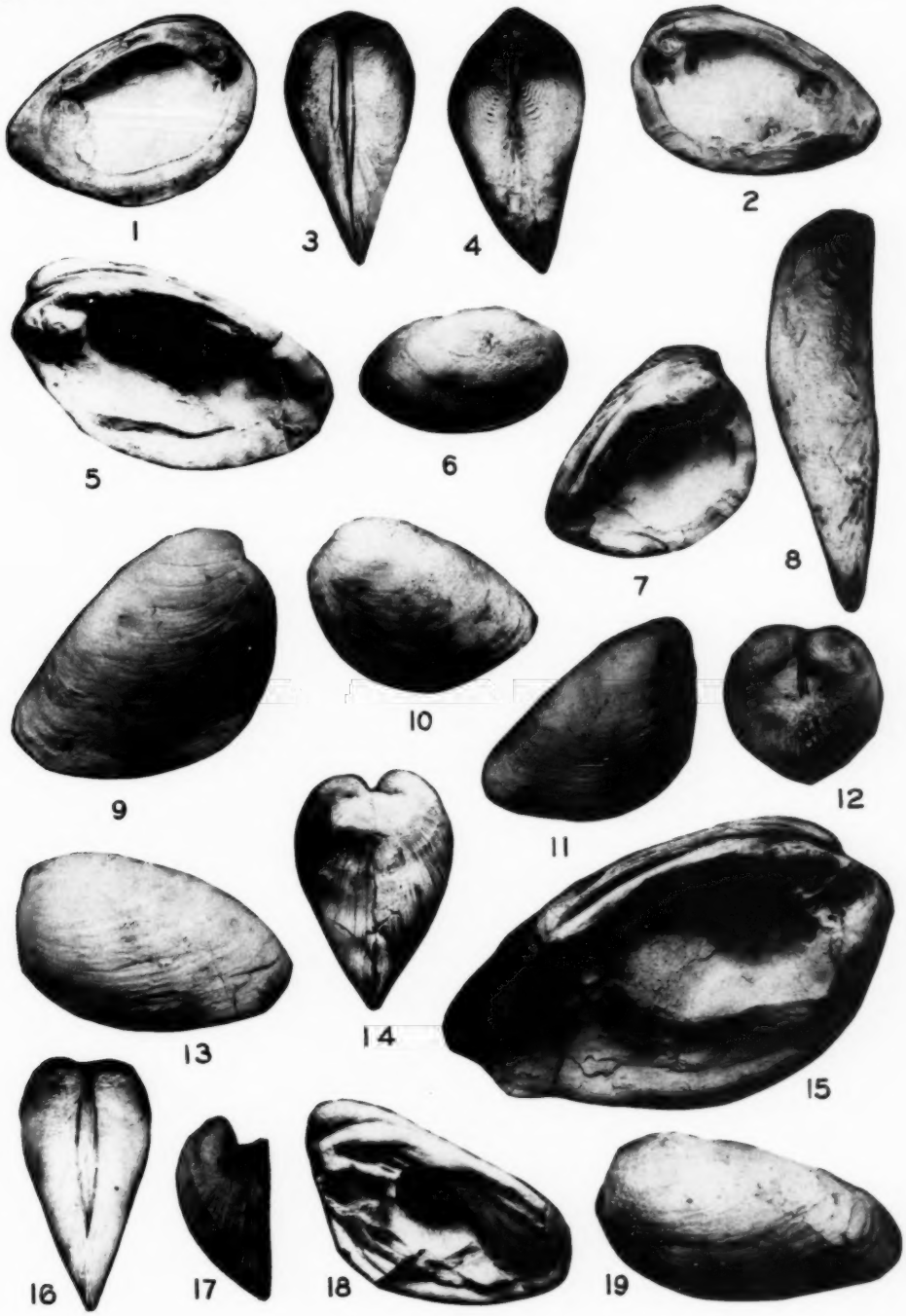
The hinge structure is massive. The right valve bears a deep nearly rectangular socket with rough lower face parallel to the hinge below the beak and a long high ridge-like tooth parallel to and below the socket. The lateral tooth is massive and is central on the hinge. The left valve bears a single massive cuneiform

EXPLANATION OF PLATE 56

FIGS. 1–5, 8–10, 12, 13, 15, 19—*Vetulonaia whitei* C. C. Branson, n. sp. 1, Interior of left valve of holotype, ×7/10. 2, Interior of right valve of holotype, ×7/10. 3, Dorsal view of holotype, ×7/10. 4, View of beaks of a paratype, ×7/12. 5, Interior of right valve of an oblique specimen, ×7/8. 8, Dorsal view of a paratype, ×1 3/4. 9, Right valve of an oblique specimen, ×7/8. 10, Left valve of holotype, ×5/8. 12, Anterior view of an elongated specimen, ×5/7. 13, Left valve of an oblique specimen, ×7/8. 15, Interior of a large left valve, ×7/8. 19, Left valve of an elongated specimen, ×5/7. (p. 517)

6—*Vetulonaia*? *nucalis* (Meek and Hayden); right valve of a small specimen, ×5/7. (p. 518)

7, 11, 14, 16–18, *Vetulonaia mayoworthensis* C. C. Branson, n. sp. 7, Interior of a left valve, ×7/8. 11, Right valve of the holotype, ×5/7. 14, Anterior view of a complete specimen, ×7/8. 16, Dorsal view of a complete specimen, ×7/8. 17, Anterior view of the holotype, ×7/8. 18, Interior of the holotype right valve, ×7/8. (p. 518)



C. C. Branson, Jurassic (?) Pelecypods

pseudo-cardinal tooth which is rough on its lower side. The lateral socket is deep and is flanked by a pair of lateral teeth. The anterior muscle scar is circular, deep, and lies at the anterior margin opposite the small sinus. The holotype is 47 mm. long, and 27 mm. high.

Remarks.—No other asymmetrical *Unio* of this type is known below the Laramie. A number of specimens in the collection establish something of a gradation to *Vetulonaia whitei*, but the end form is easily distinguished. *Unio hamili* McLearn from the lower Blairmore of Alberta has a similar ornamentation and shape, but the beaks are not so nearly terminal, the concentric wrinkles extend farther from the beak and no radial undulations are known.

The species is named for Mayoworth Post Office, Wyoming, which is near the collecting locality.

Subphylum GASTROPODA

VALVATA SCABRIDA Meek and Hayden

Valvata? scabrida MEEK and HAYDEN, *1865*, Smithsonian Contr. to Knowledge, vol. 14, p. 113, pl. 4, fig. 2.

Valvata scabrida? WHITE, *1886*, U. S. Geol. Survey, Bull. 29, pp. 22, 23, pl. 4, figs. 1–3, 19.

Valvata leei LOGAN, *1900*, Kansas Univ. Quart., vol. 9, pp. 133, 134, pl. 31, figs. 1–3.

Meek and Hayden's types (U. S. Nat. Mus., 316) are two specimens in a slab, one of which is still embedded in the matrix the other is crushed in such a way that the last whorl is pushed to one side and the spire now rests upon it. Meek and Hayden's figure cannot be considered a true representation of the appearance of the shell. The Colorado specimens which White doubtfully identified as this species are like the types, but have a slight shoulder at the outer margin of the whorl. Logan's species is said to differ chiefly in the lesser elevation of the spire, but as Meek and Hayden's figure exaggerates the height of the spire, this difference does not hold. My specimens agree with the specimens of White, but the preservation is too poor for definite identification.

VALVATA? JURASSICA C. C. Branson, n. sp.
Plate 57, figures 7, 8

Spire slightly elevated, of four volutions, last whorl many times larger than previous whorls and rapidly increasing in size in the last half volution; suture distinct, flanked by a narrow plane area at the top of the last volution; peristome complete; umbilicus deep, circular, with nearly vertical sides. Surface of shell marked by about thirty revolving spirals and by fine growth lines. Diameter of holotype 3.3 mm., height 1.6 mm.

V. scabrida Meek and Hayden has a higher spire and lacks spirals; *V. nana* Meek is more discoidal in shape.

LIOPLACODES VETERNUS Meek and Hayden?
Plate 57, figure 11

A single specimen has the ornamentation and high spire of this species. *L. veternus* and *Neritina nebraskensis* were collected from a locality near the head of Wind River, Wyoming, and the Morrison age of the beds has been questioned. The occurrence of *L. veternus* at Mayoworth, if definitely established, would place both species in the Morrison.

VIVIPARUS GILLI Meek and Hayden
Plate 57, figures 9, 10

This species is abundantly represented at Mayoworth and the specimens are typical. An average specimen is 4 mm. high, 2.8 mm. in diameter, and has an apical angle of 70 degrees.

PLANORBIS VETERNUS Meek and Hayden
Plate 57, figures 12, 13

This species is represented by an abundance of specimens. They agree with White's types (U. S. Nat. Mus., 20057) and figures. The original types of Meek and Hayden are poorly preserved and useless (U. S. Nat. Mus., 317). An average specimen from Mayoworth is 4 mm. in diameter and 1.5 mm. high.

PENTAGONIOSTOMA C. C. Branson, n. gen.

Fresh-water gastropods with depressed or low spire, volutions with strong median carina and bounded above and

below by carinae, aperture large, pentagonal: umbilicus wide open, deep; shell surface marked by oblique carinae.

The type species bears a very close resemblance to *Adeorbis supranitidus* Wood., a marine shell of Oligocene to Recent age. I was inclined to refer the Morrison form to that genus, but on the advice of Dr. J. B. Reeside, I am erecting a new genus for it. The umbilicus of *Adeorbis* is much larger and deeper and the shell appears to be thinner.

Etymology, Greek *penta-*, five; *gonia*, angle; *stoma*, mouth. Genotype, *P. jurassicum* C. C. Branson, n. sp.

PENTAGONIOSTOMA JURASSICUM
C. C. Branson, n. sp.
Plate 57, figures 4–6

Spire flat or slightly elevated, of four volutions; the top of the whorl concave with a strong marginal carina elevated above the surface of the whorl and projecting over the slightly concave lateral face of the whorl. A strong carina occupies the center of the lateral face of the whorl and the lateral slopes incline outward to the carina. The lower shoulder of the whorl bears a carina less prominent than the other carinae. The umbilicus is open, deep, and steep-sided. The aperture is nearly pentagonal. The entire surface of the shell is marked by fine transverse lines which are slightly oblique outwards and backwards and which form slight nodosities where they cross the carinae. A large specimen is 6.5 mm. in diameter and 3 mm. high.

Remarks.—The species is close to *Adeorbis supranitidus* S. Woodward of the Oligocene to Recent of the Atlantic shores. The Morrison form has a flatter upper shoulder with the carina standing above it and does not have the downward and outward inclination of the whorl as in the Atlantic species.

PENTAGONIOSTOMA ALTISPIRATUM
C. C. Branson, n. sp.
Plate 57, figures 1–3

Shell about as wide as high; spire elevated, of three volutions; protoconch turned downward and tucked under; first volution circular in cross-section; second whorl with flat upper shoulder, slightly depressed below a marginal carina; lateral slope of whorl a plane, outward slope to a median carina which is only slightly above the overlap of the last whorl. Upper shoulder of last whorl concave, bounded by a strong carina which is elevated above the shoulder and overhangs the lateral slope. Side of whorl slightly concave above and below a sharp prominent median carina. Lower margin of lateral slope bounded by strong

EXPLANATION OF PLATE 57

FIGS. 1–3—*Pentagoniostoma altispiratum* C. C. Branson, n. sp. 1, Lateral view of holotype, showing aperture, ×5. 2, Lateral view of holotype, ×5. 3, Dorsal view of holotype ×5. (p. 520)

4–6—*Pentagoniostoma jurassicum* C. C. Branson, n. sp. 4, Lateral view of a syntype showing aperture, ×5. 5, Dorsal view of a syntype, ×5. 6, Ventral view of a syntype, ×5. (p. 520)

7, 8—*Valvata? jurassica* C. C. Branson, n. sp. 7, Lateral view of holotype, ×5. 8, Dorsal view of holotype, ×3. (p. 519)

9, 10—*Viviparus gilli* Meek and Hayden. 9, Lateral view of a typical specimen, ×10. 10, Same specimen, showing aperture, ×10. (p. 519)

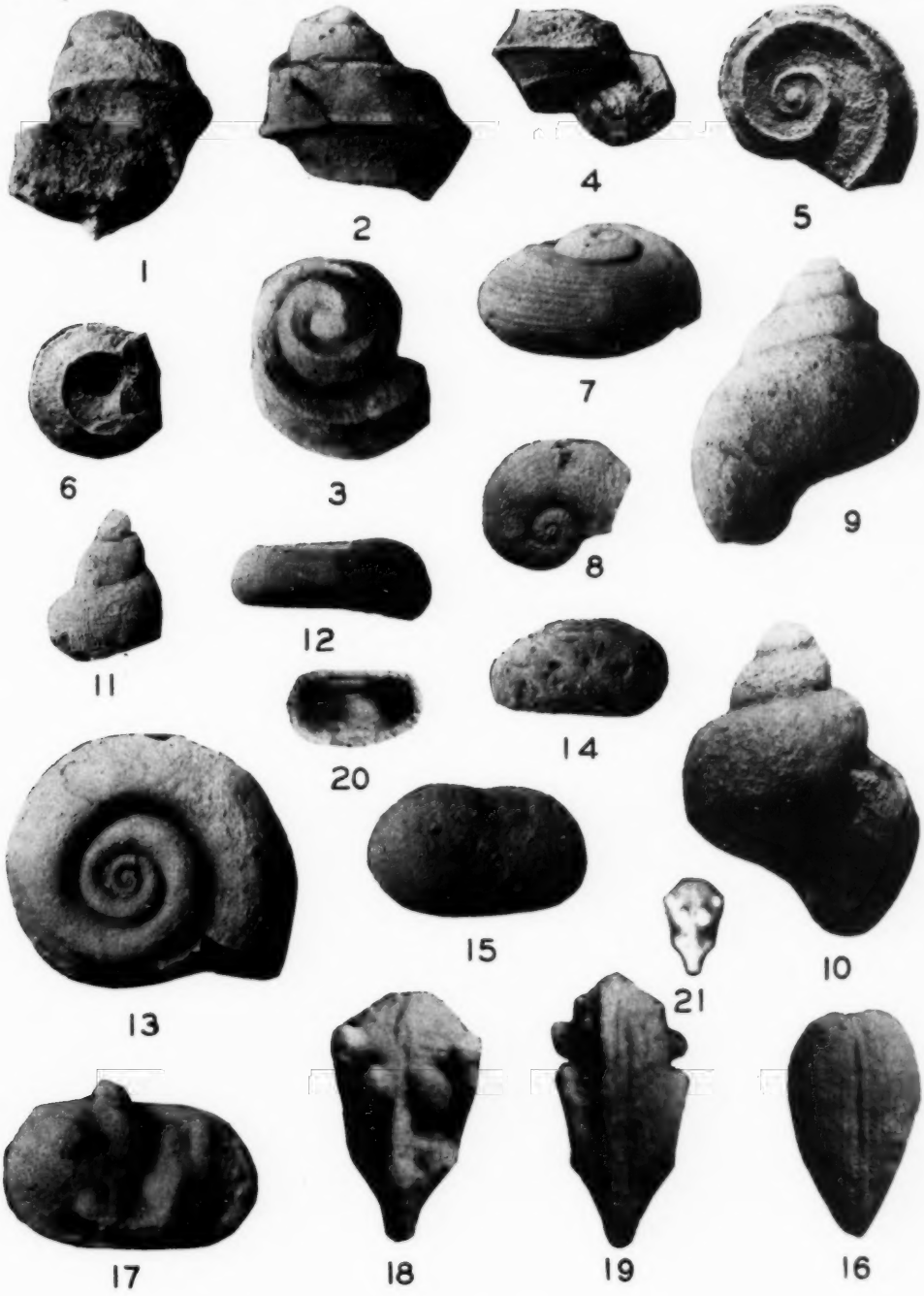
11—*Lioplacodes veternus* Meek and Hayden?; lateral view of a specimen doubtfully referred to this species, ×5. (p. 519)

12, 13—*Planorbis veternus* Meek and Hayden. 12, Lateral view of an average specimen, ×3. 13, Dorsal view of a typical specimen, ×5. (p. 519)

14—*Darwinula acuminata* (Roth)?; lateral view of an average specimen, ×30. (p. 521)

15, 16—*Metacypris minnekahtensis* (Roth). 15, Lateral view of a complete specimen, ×30. 16, Ventral view of another specimen, ×30. (p. 521)

17–21—*Morrisonia wyomingensis* C. C. Branson, n. sp. 17, Left valve of a syntype, ×30. 18, Dorsal view of a syntype, ×30. 19, Ventral view of a syntype, ×30. 20, Interior of a right valve, ×15. 21, Dorsal view of a syntype, ×10. (p. 521)



C. C. Branson, Jurassic (?) Gastropoda and Ostracoda

elevated carina and forming an acute angle to the umbilical slope. Aperture nearly pentagonal, poorly preserved in the type. Surface of shell marked by fine transverse lines which curve backward between the carinae and form slight nodes where they cross the carinae. Holotype 3 mm. high, 3 mm. in diameter.

This *species* may be distinguished from *P. jurassicum* by its elevated spire. Etymology, *altus*, high; *spira*, spiral.

OSTRACODA

Two collections of Morrison ostracodes have been described. The earlier, from Cañon City, Colorado, was studied by T. Rupert Jones, who identified *Metacypris forbesi* Jones, *Darwinula leguminella* (Forbes), *Cypris purbeckensis* Forbes, and described as new species, *Metacypris bradyi*, *M. whitei*, *Cytherideis marshi*, and *Cytheridea ? atlantosaurica*. The three previously described species are from the English Jurassic and certainly seem unlikely to occur in fresh-water deposits four thousand miles away. R. Roth described a faunule from the Black Hills in 1934 comprising *Jonesina minnekahtensis*, *J. pahasapensis*, *Bairdiocypris morrisonensis*, *B. trapezoidalis*, *Paracypris simplus*, *P. acuminatus*, and *Pseudocypridina piedmonti*, all new species. Roth seems not to have referred to Jones' paper, and of his species *Paracypris acuminatus* seems to be the Colorado form identified as *Darwinula leguminella*, *Jonesina minnekahtensis* is like *Metacypris forbesi*, and *Pseudocypridina piedmonti* is similar to *Cytheridea? atlantosaurica*. This opinion is based on the plates and descriptions only. Jones' specimens were dissolved from limestone with acid and were damaged so as to destroy ornamentation. His figures are line drawings. The writer hopes in the future to be able to collect topotype material in Colorado to compare with Roth's types.

Miss Frances Harper, of the University of Illinois, is describing a faunule from the northwestern part of the Black Hills consisting of species of *Cypris*, *Darwinula*, and a new genus of Cyprididae.

METACYPRIS MINNEKAHTENSIS (Roth)

Plate 57, figures 15, 16

Metacypris forbesii JONES, *1886*, Geol. Mag., Dec. 3, vol. 3, p. 146, pl. 4, figs. 1*a–c*.

Jonesina minnekahtensis ROTH, *1934*, Jour. Paleontology, vol. 7, pp. 399–401, pl. 48, figs. 1*a–g*.

This species is one of the rare elements in the faunule. I am comparing the Mayoworth forms with the Colorado forms and referring them to Roth's species.

DARWINULA ACUMINATA (Roth)?

Plate 57, figure 14

Darwinula leguminella JONES (not Forbes), *1886*, Geol. Mag., Dec. 3, vol. 3, p. 147, pl. 4, figs. 4*a–c*.

Paracypris acuminatus ROTH, *1934*, Jour. Paleontology, vol. 7, p. 404, pl. 48, figs. 5*a–c*.

My specimens are poor and are doubtfully referred to this species.

Genus MORRISONIA

C. C. Branson, n. gen.

Forms expanded anteriorly, compressed posteriorly, with the ventral swing at the posterior end. Valves divided medially by a strong median sulcus above a crescentic ridge, and further marked by strong nodes into four parts. Hinge straight, short, a ridge on the right valve fitting into a groove in the left valve in the central part of the hinge.

MORRISONIA WYOMINGENSIS

C. C. Branson, n. sp.

Plate 57, figures 17–21

Valves subquadrangular, compressed posteriorly, expanded anteriorly; anterior margin broadly rounded, posterior margin with ventral swing so that maximum length is measured near the ventral margin, ventral margin straight through posterior three-fourths of length through anterior portion, dorsal margin straight. A prominent crescentic ridge lies centrally near the ventral margin, the posterior end turned dorsad and terminating in an irregular hemispherical node. The

adjacent area above and behind this node is elevated and bears a small rounded node near the dorsal margin, behind which is a shallow short sulcus setting off a small node which appears to be an elongation of the crescentic ridge. The area near the posterior margin is plane. Anterior to and inside of the crescentic ridge is a deep median sulcus extending from the crescentic ridge to the dorsal margin and dividing the shell into a compressed posterior portion and an expanded anterior portion. In front of the sulcus near the dorsal margin is an anteriorly oblique elongate cylindrical node which extends well above the dorsum. Anterior to this node is a shallow sulcus in front of which and above the center of the anterior lobe is a prominent hemispherical node, possibly an eye tubercle. In lateral view the valves are bounded by a false keel which extends from the center of the anterior margin around the ventral margin and the posterior margin to the posterior corner of the hinge. The surface of the valves is marked by subquadrangular pits except in the various sulci. The pits on the distal part of the cylindrical node are elongate.

The ventral surface is broad and bears pairs of false keels arranged en echelon. The first keel begins on the anterior margin and extends past the center of the venter. The second keel is introduced inside of the first near the anterior end of the venter, becomes the outer and stronger keel near the center of the shell, and is continued backward in the compressed posterior corner of the ventral side of the shell. Two or three additional pairs of keels are introduced in sequence inside of the first two pairs, and the final pair extends to the dorsal corner of the posterior margin.

Hinge short, central, not overlapping; a ridge on the right valve fits into a groove on the left valve in the central portion of the hinge. About fifty specimens were collected, all of about the same size. An average specimen is 1.3 mm. long, 0.9 mm. high, and 0.6 mm. wide.

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ROTALIA VIENNOTI, AN IMPORTANT FORAMINIFERAL SPECIES FROM ASIA MINOR AND WESTERN ASIA[1]

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ABSTRACT

A new species of foraminifera, *Rotalia viennoti*, is described, and its range and geographical distribution, as known at present, are given.

From the time of its discovery in Persia in 1930 until quite recently, the new foraminifer described in this article had been known and recognized only in thin-sections of limestones. It was first noted in upper and lower Lutetian limestones of Surkh-i-dizeh, W. Persia. Subsequently it was found in upper Lutetian limestones of the Kirkuk oil field, Iraq, and also in the Maestrichtian of Dohuk, Iraq, not far from the Turkish and Kurdish frontiers. In 1932, it was again noted by me in limestone sections of Oligocene and Lutetian age in Palestine from three localities: (*a*) at Nablus, Mt. Gerizim, north of Jerusalem; (*b*) at a point 24 miles west-southwest of Jerusalem and 1.5 miles west of Beit Jibrin; and (*c*) near Tulkarem. Almost concurrently, but quite independently, geologists of the Iraq Petroleum Company also recognized the organism at several points in Palestine and were successful in isolating complete specimens from their matrix. Mr. F. R. S. Henson, of the above-mentioned company, then kindly forwarded numerous specimens to me in order that a description of the new species could be made public.

In 1930, shortly after its discovery, the new species was assigned tentatively to the family Rotaliidae and given a new generic manuscript name by the late M. Pierre Viennot of Paris, to whom I had referred the specimens for complete determination. My further researches have confirmed Viennot's opinion that the species should be included in the Rotaliidae, but a new generic name hardly seems to be warranted, as the organism, apart from its ornamentation, appears to be structurally very similar to *Rotalia* proper, as described by Lamarck in 1804.

The new specific name, *Rotalia viennoti*, proposed in this paper, has been given in memory of this zealous worker on the foraminifera, whose untimely death robbed him of the chance of describing the new species himself.

[1] Published by kind permission of the Standard Oil Co. of New Jersey and the Iraq Petroleum Company.

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Family ROTALIIDAE

Subfamily ROTALIINAE

Schultze, 1854.

Genus ROTALIA Lamarck, 1804

ROTALIA VIENNOTI Greig, n. sp.

Test calcareous, coarsely perforate, very strong. Although usually hidden by surface ornamentation, all whorls present on dorsal side, only the last whorl present on the ventral. Walls thick and test stiffened in the center by vertical pillars which extend from the nucleoconch and terminate in big pustules on the exterior. Test roughly circular and trochoid, the shape varying from almost planoconvex to subglobular in vertical aspect; chambers spirally coiled, seldom more than three whorls in number, both clockwise and counterclockwise coiling being equally common.

Aperture peripheral and slightly ventral, near the base of the apertural face; in the young, consisting of a plain split, and in the adult of irregular openings near the base of the last-formed chamber, their configuration being controlled to a certain extent by the pustular arrangement of the previous whorl; the apertural face occasionally bounded by a thin non-pustular lip. Exterior of test completely covered with small pustules, including the periphery; in the young, the pustules on the dorsal surface may be roughly spirally and radially arranged, and take the place of limbate sutures or costae; in the adult, larger pustules grow towards the center of the dorsal and ventral surfaces, with the biggest development filling the umbilical region. So far, only megalospheric forms have been recognized.

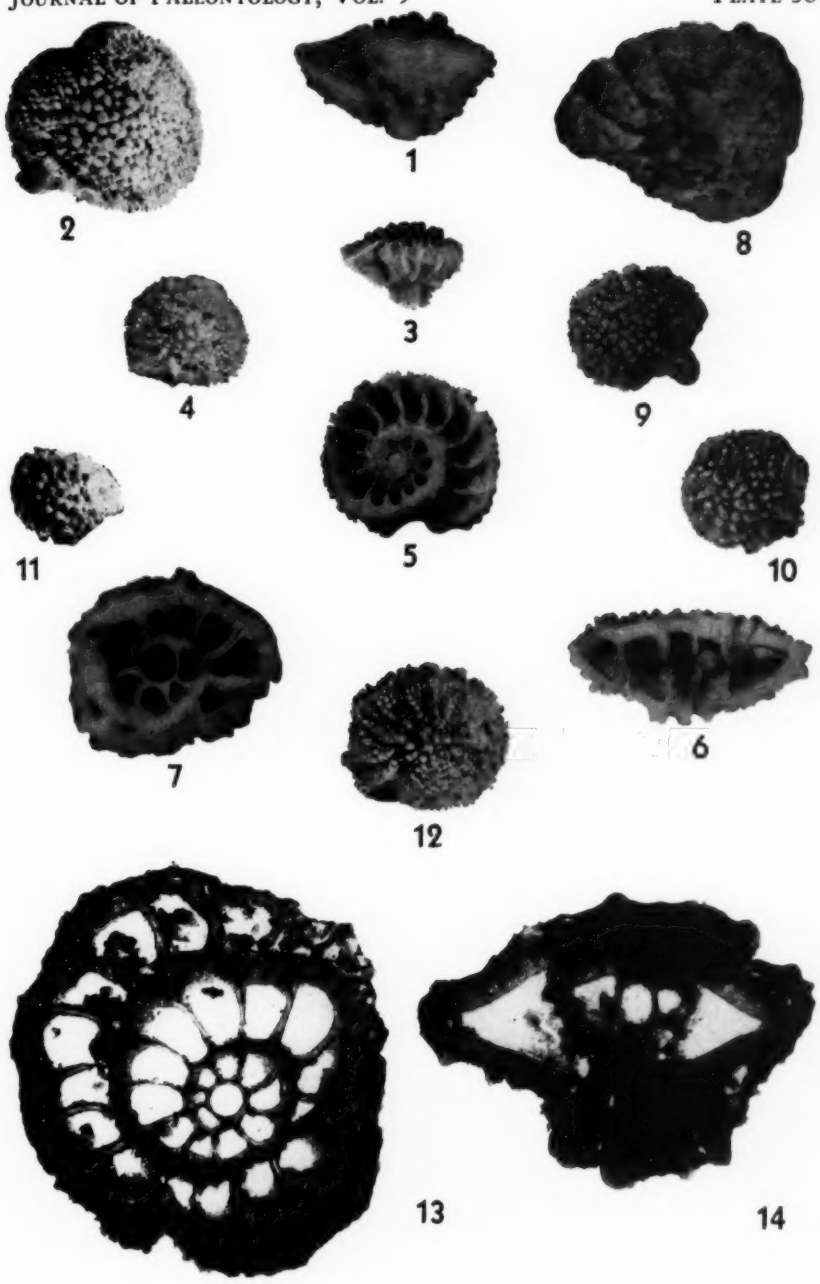
Internal characters seen in thin section: (1) Equatorially, (see Pl. 58, fig. 13), a typical canal system visible; spiral fairly regularly coiled and usually not more than three whorls in number; average diameter of megalosphere, 0.2 mm.; (2) Vertically, (see Pl. 58, fig. 14), test trochoid with typical development of massive pillars towards the center, especially in the umbilical region.

The diameter of well-grown individuals of *Rotalia viennoti* averages 2.0 to 2.5 mm. It seldom exceeds 3 mm.

EXPLANATION OF PLATE 58

FIGS. 1–14—*Rotalia viennoti* Greig, n. sp., from the Oligocene of Ramleh, Palestine. 1, Left-handed specimen, apertural view (×26), B. M., P.31580. 2, Left-handed specimen, dorsal view (×11.5), B. M., P.31581. 3, Left-handed specimen, apertural view, showing apertures just visible (×9.6), B.M., P.31582. 4, Left-handed specimen, dorsal view showing apertural lip (×10.3), B. M., P.31583. 5, Median equatorial section (×10.5), B. M., P.31584. 6, Tangential vertical section (×27), B. M., P.31585. 7, Broken specimen, showing megalosphere equatorially, (×24), B. M., P. 31586. 8, Worn specimen, showing sutures (×11), B. M., P.31587. 9, Right-handed specimen, dorsal view (×9.7), B. M., P.31588. 10, Right-handed specimen, dorsal view (×10.2), B. M., P.31589. 11, Right-handed specimen, dorsal view (×11), B. M., P.31590. 12, Right-handed specimen, ventral view showing pustules arranged radially (×10.8), B. M., P.31591. 13, Thin-section, equatorial view (×25), B. M., P.31592. 14, Thin-section, vertical view of a specimen like figure 3 (×35), B. M., P.31593. (p. 524)

All the specimens illustrated on this plate are now in the British Museum of Natural History, London, and their register numbers are given.



Greig, Tertiary Foraminifera

Remarks.—From the above description and an examination of the accompanying photographs, it may be argued that the pillars so strongly developed in the central region indicate a very definite structural difference from a true *Rotalia*, and that they play a functional part in supporting and strengthening the rather heavy test. And naturally, if such could be proved, a new generic name as suggested by Viennot might have been given, as the erection of a new genus would then have been clearly indicated. But forms with a somewhat similar ornamentation, such as *Rotalia defrancei* d'Orb, *R. calcar* d'Orb, and *R. schroeteriana* Parker and Jones would also have to be included in the new genus, particularly as *R. viennoti* appears to be closely related to *R. schroeteriana*. This uncertainty will unfortunately have to remain, however, until a really detailed and extensive revision of the Rotaliidae can be undertaken, and for the sake of avoiding needless confusion in the nomenclature at the present time, it seems best to consider the central pillars in *R. viennoti* as purely ornamental and of no definite functional significance. No new generic name is, therefore, offered to cover these four elaborately ornamented Rotaliae, although it is believed that further research may eventually prove the necessity for it.

Broadly speaking, *R. viennoti* differs externally from *R. schroeteriana* by having a much more irregular arrangement of the surface pustules, and a bigger development of them altogether. Moreover, in some specimens of *R. viennoti*, it is not at once apparent which is the dorsal and which the ventral surface, while these are immediately distinguishable in *R. schroeteriana*. Internally, *R. schroeteriana* has no well-marked central pillars, as has *R. viennoti*.

R. calcar and *R. defrancei* are much easier to differentiate from *R. viennoti*, as they both possess a markedly peripheral development of spines, and the central pillars, which are such a distinctive feature of *R. viennoti*, are not present at all.

The chief difference between *R. viennoti* and the genotype, *R. trochidiformis*, is that the latter has a perfectly smooth dorsal surface upon which the coiling is clearly visible, and that it has small pustules developed only on the ventral surface. The central pillars, which are so typical of *R. viennoti*, are absent in this species also.

Distribution and Range.—Rotalia viennoti has now been noted by various workers from the following countries: (1) Western Persia, near Surkh-i-dizeh, in the upper and lower Lutetian; (2) Northern Iraq, near Dohuk, in the Maestrichtian (rare), and in the Kirkuk area, in the upper Lutetian; (3) Palestine, near Nablus, Mt. Gerizim, near Tulkarem, and near Ramleh, all in the Lutetian and Oligocene; (4) Syria, widely distributed throughout the Syrian "Aire Continentale", in rocks of middle Eocene and Oligocene; and (5) Malta, where some specimens have been noted by Henson in M. H. Douvillé's collection at the School of Mines, Paris, from the "lower

Coralline limestone" (Oligocene).

The earliest known occurrence of *R. viennoti* is in the Maestrichtian of northern Iraq, but it has been noted only very rarely in that formation. It is not until the Eocene that the species became abundant and at all widespread.

In the Lutetian of northern Iraq, for example, *R. viennoti* occurs in large numbers in association with various discocyclines, (such as *Orthophragmina* spp., *Asterocyclina* sp., *Aktinocyclina* spp.), *Alveolina oblonga* Schwager, *Alveolina* cf. *frumentiformis* Schwager, various *Nummulites*, *Lituonella liburnica* Silv., *Gypsina* sp., and other forms.

In the Lutetian of Palestine, it is associated with an assemblage consisting of *Nummulites gizehensis* Forskal, *N. lucasanus* Defrance, *Alveolina* cf. *elliptica* Sowerby, *Asterocyclina* sp., *Planorbulinella* sp., and others.

In the Oligocene of Palestine, *R. viennoti* often occurs in calcareous marls associated with a big microfauna containing many orbitoids, for a description of which the reader is referred to a paper to be published very shortly by Henson. This same Oligocene of Palestine also contains a good macrofauna, and the larger fossils have already been described by L. R. Cox, of the British Museum of Natural History (see Cox, Geol. Mag., 1934, p. 337).

From a glance at the lists of associated microfossils, it is clear that *R. viennoti* was a form living in warm and fairly shallow sea-water, probably at depths not exceeding 30 fathoms.

By reason of its easy identification both in hand-specimen and thin-section, and from the fact that it has a relatively restricted time-range (Maestrichtian to Oligocene), *Rotalia viennoti* has assumed a certain degree of stratigraphical importance during the past two years, and is becoming well-known to a number of workers. Further details of its distribution will be awaited with interest.

Types.—The figured specimens (paratypes) and supplementary material have been placed for reference in the British Museum of Natural History, London. The specimen shown in Plate 58, figure 12, has been selected as the holotype of the species.

For the benefit of American workers, additional specimens have also been placed in the Museum of the Cushman Laboratory of Foraminiferal Research, Sharon, Massachusetts.

Acknowledgments.—I wish to express my indebtedness to Mr. F. R. S. Henson, senior subsurface geologist of the Iraq Petroleum Company for presenting me with isolated specimens of *R. viennoti*, and for much helpful criticism in the preparation of this paper. Thanks are also due to Mr. G. S. Blake, Geological Adviser to the Palestine Government, who collected certain material which was examined by me in 1932, and also to the paleontological staff of the British Museum of Natural History for collaboration and the loan of additional specimens. The photographs are the work of Mr. G. S. Sweeting, D. I. C., F. G. S., of the Royal School of Mines, London.

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LARGER FORAMINIFERA OF NORTHERN SANTA CLARA PROVINCE, CUBA

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ABSTRACT

This paper discusses faunas of larger foraminifera of Oligocene, upper Eocene and Upper Cretaceous age from the northern part of Santa Clara province, Cuba. *Camerina macgillavryi*, *C. petri*, *C. malbertii* and *Discocyclina vermunti* are new forms described from the upper Eocene. *Lepidorbitoides planasi* is described from the Upper Cretaceous. The genus *Asterorbis* Vaughan and Cole is placed under *Lepidorbitoides* Silvestri [=*Orbitocyclina* Vaughan], together with the new subgenus *Cryptasterorbis* with the type-species *Cryptasterorbis cubensis* (Palmer). The internal structure of the genus *Pseudorbitoides* Douvillé is discussed and a new subfamily, the Pseudorbitoidinae, proposed.

The material here described was collected in the first half of 1933, when a party from the University of Utrecht, Holland, under the leadership of Prof. L. M. R. Rutten, visited this region for geological reconnaissance work. All observations bearing on northern Santa Clara were allotted to me as a basis for a thesis describing the geology of this country. The notes on foraminifera are published here, but details of geologic and tectonic nature will appear later.

The localities mentioned are indicated on the accompanying sketch maps (fig. 1), the letters H or L preceding the field-numbers indicating, respectively, the collectors, H. J. MacGillavry and L. M. R. Rutten. The Tertiary foraminifera, with the exception of *Camerina macgillavryi*, were collected from a loose grit and are well preserved. Most of the Cretaceous specimens were obtained from a soft grayish limestone, but have undergone a more or less thorough process of recrystallization. In the remaining cases numerous thin sections had to be made.

All the specimens described are in the Mineralogisch-Geologisch Instituut of the University of Utrecht, Holland. The numbers preceded by a D are in the microscopic thin-sections collection of that Institute.

The faunas of the different locali-

Foraminifera of Oligocene age

Localities	H 71	H 80	L 156	L 157
Lepidocyclina fragilis Cushman	—	—	—	r
Lepidocyclina marginata (Michelotti)	r	—	r	a
Lepidocyclina piedrasensis Vaughan	—	r	r	a
Lepidocyclina tournoueri Lemoine and R. Douvillé	r	r	c	—
Lepidocyclina semmesi Vaughan and Cole	—	—	r	—
Lepidocyclina favosa Cushman	a	a	a	—

r=rare; c=common; a=abundant.

Foraminifera of upper Eocene age

Localities	H 61	H 63a	H 66	H 374	H 381	H 384	H 392	H 636	L 158	L 393
Camerina macgillavryi Rutten, n. sp.	—	—	—	—	—	—	—	a	—	—
Camerina malbertii Rutten, n. sp.	—	r	c	—	—	—	—	—	r	—
Camerina petri Rutten, n. sp.	a	a	a	a	r	—	—	—	a	—
Camerina sp. (Palmer)	—	—	—	a	r	r	—	—	—	—
Operculina sp.	r	r	r	—	—	—	—	—	—	—
Heterostegina panamensis Gravell	—	—	—	r	—	—	r	—	—	—
Lepidocyclina r.-douvillei Lisson	—	—	r	—	—	—	—	—	r	—
Lepidocyclina georgiana Cushman	—	—	a	r	—	—	—	—	—	—
Lepidocyclina meinzeri Vaughan	—	—	r	r	—	—	r	—	—	—
Lepidocyclina mortoni Cushman	—	—	r	a	—	—	r	—	—	—
Lepidocyclina pustulosa H. Douvillé	c	—	—	r	—	—	r	—	c	—
Lepidocyclina piedrasensis Vaughan	c	—	—	—	—	—	—	—	r	—
Lepidocyclina semmesi Vaughan and Cole	—	—	r	a	—	—	—	—	—	—
Helicolepidina spiralis Tobler	—	—	—	c	—	—	—	—	r	—
Discocyclina blumenthali Gorter and van der Vlerk	—	r	—	—	—	—	—	r	—	—
Discocyclina cloptoni Vaughan	—		—	—	—	—	—	a	—	a
Discocyclina cubensis (Cushman)	—	a	a	—	r	—	—	—	—	—
Discocyclina perkinsi Vaughan	—	—	—	r	—	—	—	—	—	a
Discocyclina georgiana	r	—	—	—	—	—	—	—	—	—
Discocyclina kugleri Gravell	—	—	—	r	—	r	—	—	—	—
Discocyclina vermunti Rutten, n. sp.	r	—	r	a	—	—	r	—	—	—
Discocyclina (*Asterocyclina*) sp.	—	—	—	r	—	—	—	r	—	—

r=rare; c=common; a=abundant.

Foraminifera of Upper Cretaceous age

Localities	H 153	H 160	L 415	L 485
Orbitoides browni (Ellis)	a	a	—	c
Lepidorbitoides minima H. Douvillé	—	—	—	a
Lepidorbitoides planasi Rutten, n. sp.	—	—	—	a
Lepidorbitoides cubensis (Palmer)	c	—	—	a
Lepidorbitoides aguayoi Palmer	c	—	—	—
Lepidorbitoides rooki Vaughan and Cole	c	—	—	r
Pseudorbitoides israelskii Vaughan and Cole	a	—	a	a
Pseudorbitoides trechmanni H. Douvillé	—	—	c	—
Omphalocyclus sp.	c	—	—	—
Torreina torrei Palmer	—	—	a	—

r=rare; c=common; a=abundant.

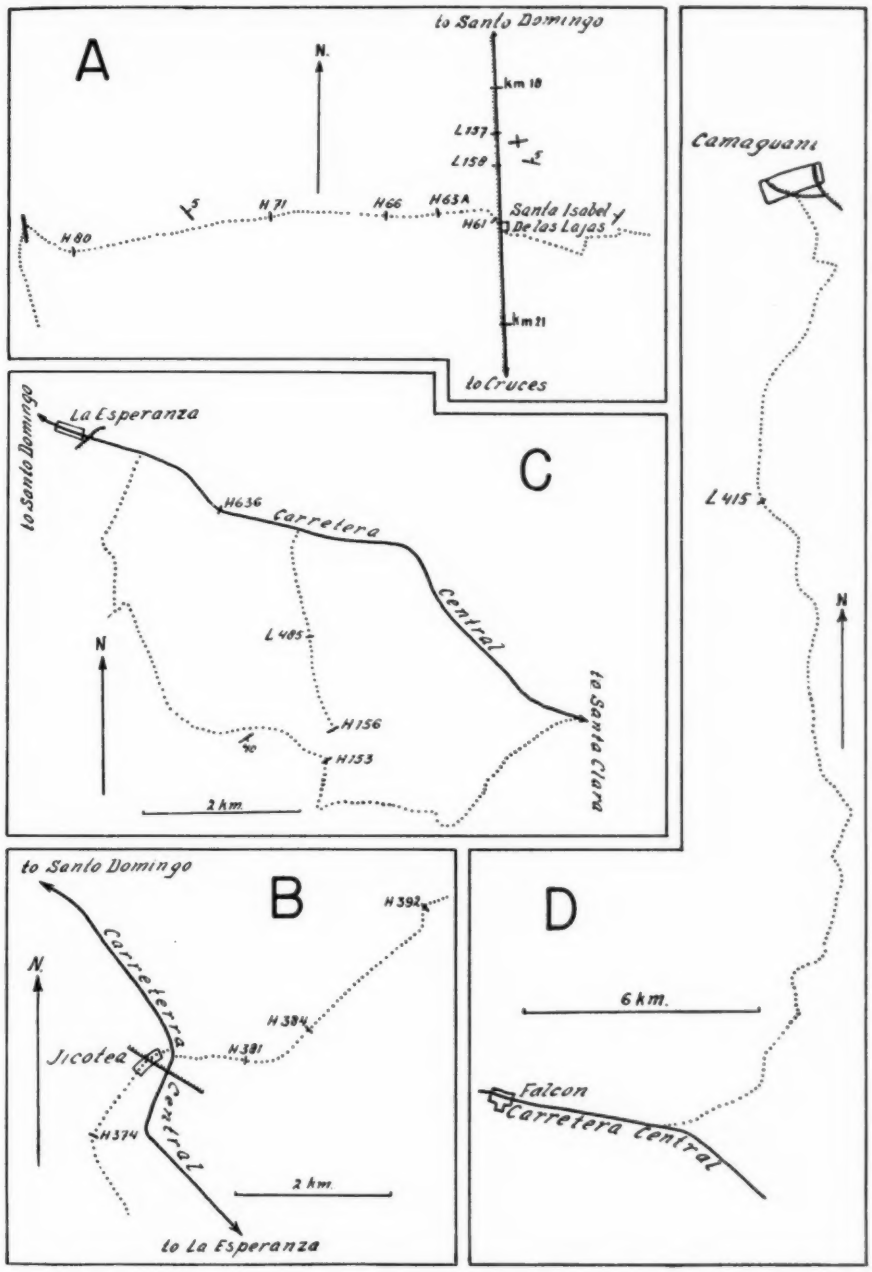


FIG. 1—A, Sketch-map of the neighborhood of Santa Isabel de las Lajas. B, Sketch-map of the neighborhood of Jicotea. C, Sketch-map of the neighborhood of La Esperanza. D, Sketch-map to show position of L 415.

ties, together with indication of age of the faunas, are given in the accompanying tables.

SYSTEMATIC DESCRIPTIONS

Genus CAMERINA Brugière, 1792

Several species of *Camerina* were found in the upper Eocene rocks of Santa Clara. Many specimens that are very similar to small Camerinas occur in sections of Upper Cretaceous rocks, but as no loose specimens of these forms could be obtained, definite identification is impossible. The Camerinas from the upper Eocene are mostly new for America. In regard to possible identification of these Cuban species with European or Asiatic forms various works dealing with "*Nummulites*" from these countries were consulted, but I was unable to examine many small publications dealing with the subject. A remote possibility remains, therefore, that the species here described are already known from Europe or Asia.

CAMERINA MACGILLAVRYI Rutten, n. sp.
Plate 59, figures 6–10; Text figure 4N

Very large microspheric forms (B) occur in association with numerous small megalospheric forms (A) in a hard white limestone. The type specimen is a microspheric form, accidentally broken through the median plane. The macrospheric form is known from thin-sections only.

Megalospheric form: Small, lenticular, involute, with an embryon consisting of one large subspherical chamber; septa curved gently backwards; chambers about as long as high.

Microspheric form: Very large and extremely thin; completely involute; most specimens irregularly curved; outer surface covered with a thick uneven layer of secondary calcite. Tangential sections show numerous small pillars, probably arranged on the septa. In the median plane the whorls, with a mean height somewhat less than 0.5 mm., are numerous, without widening towards the outer margin. The numerous septa are curved gently backwards, the chambers being about as long as high. From the sixth to the seventh whorl there are about 60 septa to a whorl.

This form differs from all known American species of *Camerina* in the large size of the microspheric form, which is also much thinner than any European species. The species is named in honor of Mr. H. J. Mac Gillavry.

Type locality, upper Eocene, Loc. H 636, on the Carretera Central, 2 km. east of the town of Esperanza, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, Pal. 1935, 298–300, D13908–13912.

CAMERINA PETRI Rutten, n. sp.
Plate 59, figures 1–5; Text figure 2

Test of medium size, lenticular, involute, radiate; granules present or ab-

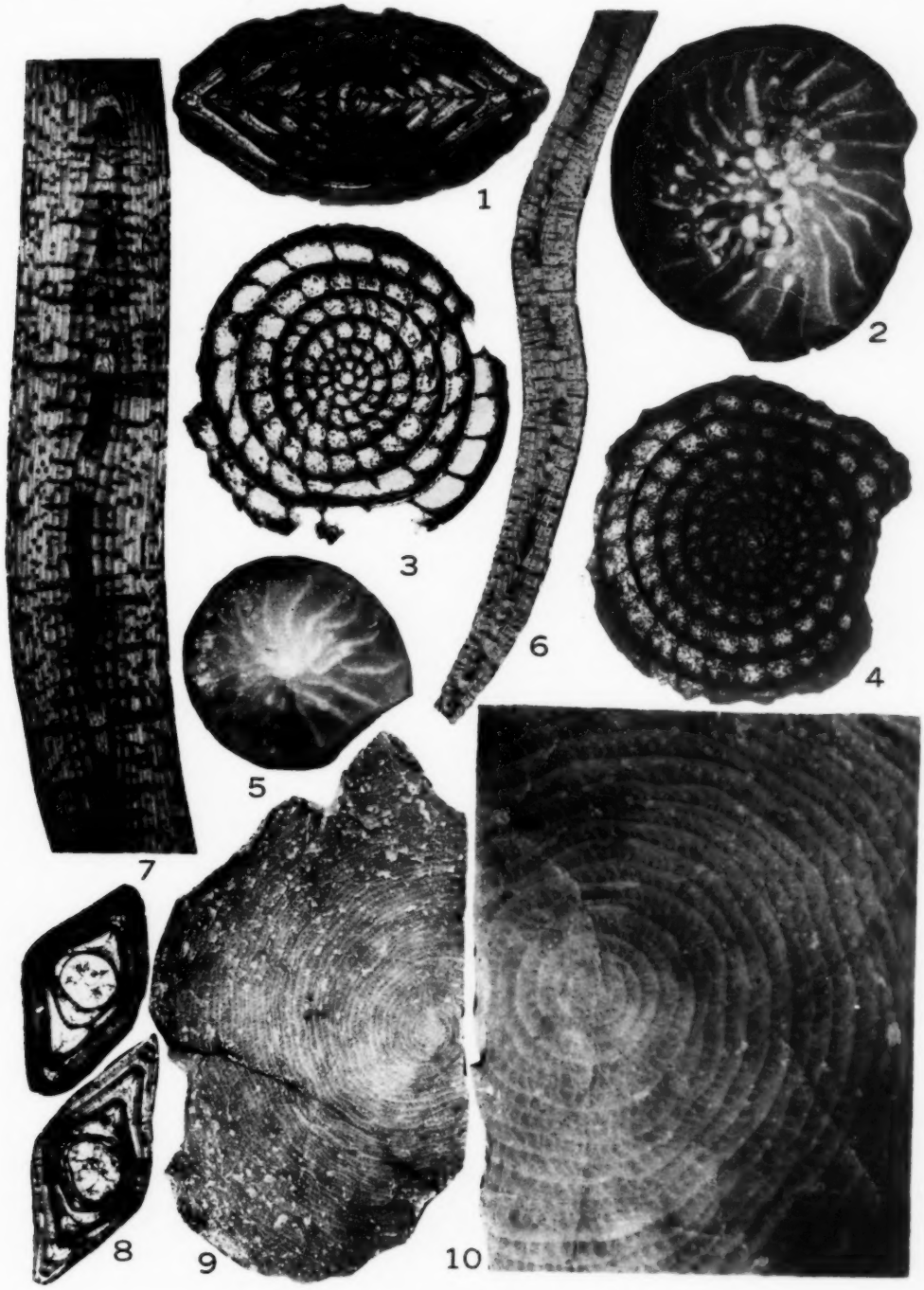
Measurements of *Camerina macgillavryi*

Form	A	A	A	A	B	B	B
Diameter	5 mm.	5.0 mm.	4.7 mm.	4.2 mm.	50 mm.	43 mm.	52 mm.
Thickness		2.1 mm.	1.8 mm.	2.0 mm.	4.5 mm.	2.7 mm.	2.4 mm.
Number of whorls	3.5	4.5	4	3.5	55	40	35
Septa to the last whorl	28						
Diameter of embryon	1.03 mm.	1.03 mm.	0.89 mm.	0.70 mm.			

EXPLANATION OF PLATE 59

FIGS. 1–5—*Camerina petri* Rutten, n. sp. 1, Vertical section, ×9. 2, External view of granulated specimen, ×7. 3, Horizontal section, ×10. 4, Horizontal section, ×6.8. 5, External view of less granulated specimen, ×10. (p. 530)

6–10—*Camerina macgillavryi* Rutten, n. sp. 6, Vertical section of microspheric specimens, ×3.8. 7, Vertical section of microspheric specimen, ×8. 8, Vertical section of macrospheric specimens, ×7.4. 9, Microspheric type specimen, ×1.6. 10, Same specimen, ×5; showing low whorls and septa gently curved backwards. (p. 530)



Rutten, Cretaceous and Tertiary Foraminifera

sent on the central part of the test; costae gently curved; several small pillars in the central part of the test. The embryon consists of one subspherical chamber varying in diameter from 0.12 to 0.30 mm. The septa are curved backwards and the chambers are longer than high, or as long as high. Diameter, thickness and number of whorls are shown in text figure 2. The number of septa to the whorl varies from 20 to 30 in the seventh or eighth whorl. Notwithstanding this considerable variation, the general appearance of all specimens is much the same, and because the number of septa varies gradually, only one species is recognized.

In general appearance *C. petri* resembles *C. matleyi* Vaughan (21), but the former is much larger. It is also larger than *C. parvula* Cushman (2), but is probably identical with *Camerina* sp. Vaughan (21, p. 377, pl. 40, fig. 7) described from Jamaica. In northern Santa Clara it is by far the commonest species of *Camerina*. The species is named in honor of Mr. Petrus Remco Pekelharing, chemist, Central Hormiguero, Cuba.

Type locality, upper Eocene, Santa Isabel de las Lajas on the railroad from Sto. Domingo to Cienfuegos, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D13920–13960.

CAMERINA MALBERTII Rutten, n. sp.
Plate 60, figures 8–10; Text figure 2

A rather large, discoidal, involute, radiate form with costae gently curved. The central area of the test may be

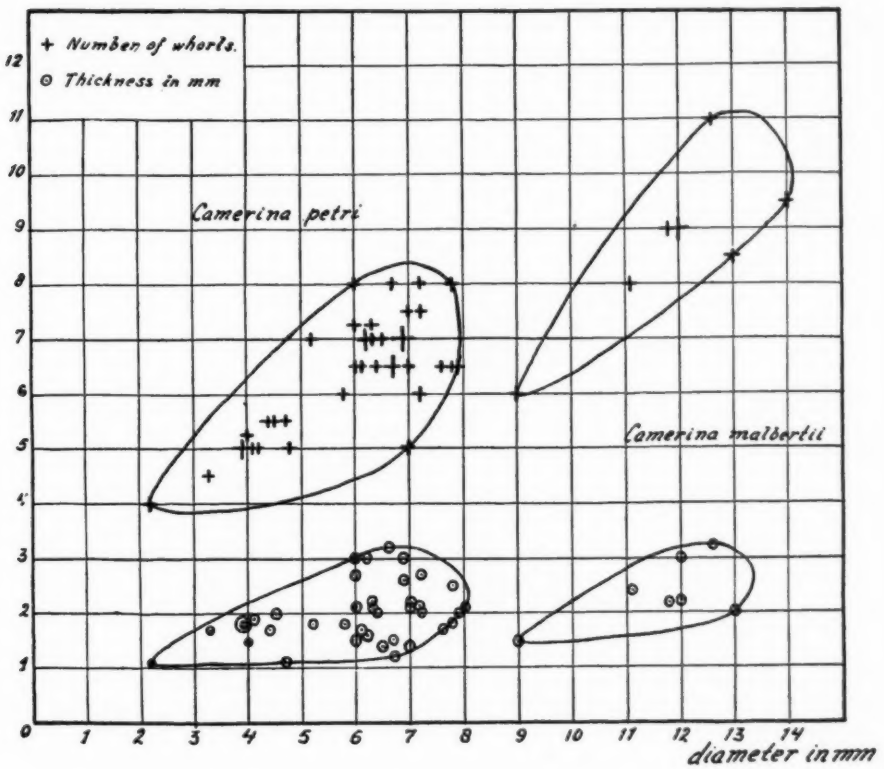


FIG. 2—Diagram showing diameters, thickness, and number of whorls of specimens of *Camerina petri* Rutten, n. sp. and *Camerina malbertii* Rutten, n. sp.

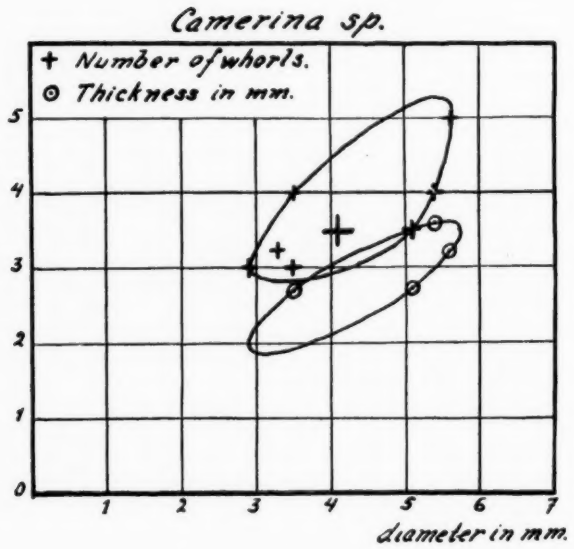


FIG. 3—Diagram showing diameter, thickness, and number of whorls of specimens of *Camerina* sp. (*Amphistegina cubensis* Palmer).

strongly granulate. Septa curved backwards, the chambers being higher than long. In the central part several small pillars occur. The diameter, thickness, and number of whorls are shown in text figure 2. The number of septa to the whorl is rather variable, being about 36 in the seventh to eighth whorl and about 40 in the ninth to eleventh whorl.

This form is closely related to the much commoner *C. petri*, but is flatter, larger and has higher chambers. Named in honor of Ing. Félix Malberti of Havana.

Type locality, upper Eocene, Santa Isabel de las Lajas, on the railroad from Sto. Domingo to Cienfuegos, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D 13912–13919.

CAMERINA sp.

Plate 60, figures 1–4; Text figure 3

Amphistegina cubensis PALMER, *1934*, Soc. Cubana de Hist. Nat., Mem., vol. 8, no. 4, pp. 256, 257, text figs. 16, 17; pl. 15, fig. 2.

The form described by Mrs. Palmer as *Amphistegina* is typical of the upper Eocene of Santa Clara. However, I consider it to be a *Camerina* rather than an *Amphistegina*, although the asymmetry of the test suggests the latter genus. I, too, could make out nothing definite as to the aperture, but the species looks like a planispirally built form with one more

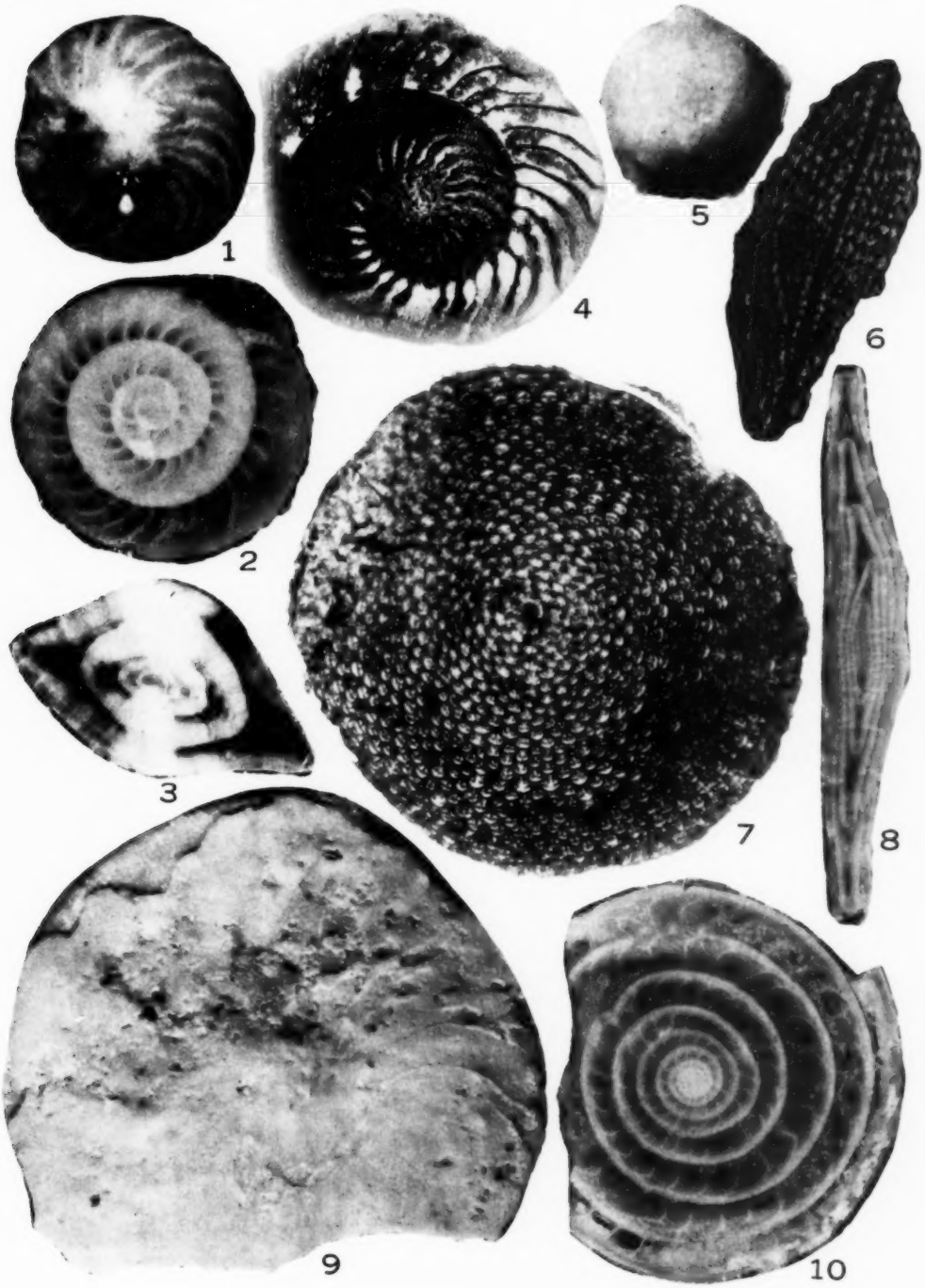
EXPLANATION OF PLATE 60

FIGS. 1–4—*Camerina* sp. 1, External view, ×10. 2, Horizontal section, slightly oblique, ×10. 3, Vertical section, ×8.2. 4, Horizontal section showing the strong backward curve of the septa, ×16. (p. 532)

5—*Lepidorbitoides* (*Cryptasterorbis*) *cubensis* (Palmer). External view showing smooth surface and short arms, ×10. (p. 536)

6, 7—*Lepidorbidoites* (*Lepidorbitoides*) *planasi* Rutten, n. sp. 6, Vertical section, ×47.5. 7, Horizontal section, ×60. (p. 536)

8–10—*Camerina malbertii* Rutten, n. sp. 8, Vertical section, ×5.5. 9, External view, ×6.7. 10, Horizontal section, ×4.7. (p. 531)



Rutten, Cretaceous and Tertiary Foraminifera

or less asymmetrical side. The asymmetry is rather variable, tending to disappear altogether in some specimens. Palmer observes that there are specimens coiled clockwise as well as counterclockwise. This supports the idea of asymmetry of left or right side of the test, which might be more or less evenly distributed according to chance. The thick shells walls indicated by Palmer (fig. 16) are due to a somewhat oblique section. A section through the equatorial plane reveals thin walls. I also did not find any secondary chambers. If the form is placed with the camerinids, there may be question as to whether it is not an *Operculina*, since the whorls widen somewhat throughout the test. However, the complete involuteness of the test and its thickness point rather to *Camerina*, s.s. In this case the form becomes a homonym of *Camerina cubensis* Palmer (15, p. 245, pl. 14, figs. 3, 5, 7), and I have asked Mrs. Palmer to give the species a new name if she agrees with my opinion.

The diameter, thickness, and number of whorls of my specimens are given in text figure 3. The number of septa to a whorl is rather variable, ranging from 21 to 31 in the fourth whorl.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 13961–13971.

Genus HETEROSTEGINA d'Orbigny, 1826

HETEROSTEGINA PANAMENSIS Gravell

Heterostegina panamensis GRAVELL, *1933*, Smithsonian Misc. Coll., vol. 89, no. 11, pp. 17, 18, pl. 1, figs. 10, 11.

Thin forms with an excentric low umbo are assigned to this species. Diameter 3 mm. to 4.1 mm.; thickness 0.9 mm. to 1.2 mm. Diameter of embryon 0.12 mm. to 0.16 mm.

Upper Eocene, northern Santa Clara Province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 13972, 13973.

Genus ORBITOIDES d'Orbigny, 1847

ORBITOIDES BROWNI (Ellis)

Gallowayina browni ELLIS, *1932*, Am. Mus. Novitates, no. 568, pp. 1–8, 9 figs. in text.—PALMER, *1934*, Jour. Paleontology, vol. 8, no. 1, pp. 68–70.

Orbitoides browni VAUGHAN, *1933*, in Cushman, J. A., Foraminifera, Key to Genera and Species, pl. 40, figs. 3, 4; *1934*, Jour. Paleontology, vol. 8, no. 1, pp. 68–70.

This form is rather abundant in Upper Cretaceous layers and even in broken sections is readily recognized by its size, strong pillars, asymmetry, and slightly dome-shaped equatorial layer. Diameter, 3.6 mm. to 6.6 mm.; thickness, 1.8 mm. to 2.7 mm.; embryonal apparatus, 0.26 $\times$0.17 mm. to 0.44 $\times$0.37 mm.

Upper Cretaceous, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 13974–13996.

Genus LEPIDORBITOIDES Silvestri, 1909

The genus *Orbitocyclina* Vaughan, 1929 is synonymous with this genus. It was based on differences of internal structure, the latter genus possessing stoloniferous apertures between the equatorial chambers. According to Douvillé the equatorial chambers in *Lepidorbitoides* communicate by means of pores in the anterior chamber-wall. Recent work on European material (28) has shown that Douvillé misinterpreted the structure of these forms and that they agree with Vaughan's description of *Orbitocyclina*. The name of Silvestri, being the older, is valid.

Subgenus CRYPTASTERORBIS Rutten, n. subgen.

A number of types of orbitoidal foraminifera of the same general form are numerous in the Upper Cretaceous rocks of Santa Clara, and especially in the limestone hills southeast of La Esperanza. We find here several species of *Lepidorbitoides* and forms that can be assigned to the genus *Asterorbis* Vaughan and Cole (26). The latter genus was described by the authors as closely related to *Orbitocyclina*. Palmer has described several forms specifically, which she placed with question under *Asterorbis* for her specimens were too poorly preserved to allow positive identification. My speci-

mens have suffered from recrystallization but give good views of the internal structure. The stellate forms show an embryonal apparatus consisting of one small subspherical first chamber, succeeded by a kidney-shaped larger one which partly embraces the first chamber. Following these are one or more chambers larger than the equatorial chambers and smaller than the preceding embryonic chambers. They partly embrace the two chambers. The equatorial chambers are low and arcuate. The outer walls of the chambers in one circle form the inner walls of the chambers in the following circle, just as in *Orbitocyclina*. The pattern is obscured by black radial lines occurring in almost every chamber. These are due to recrystallization. They have about the length of the chambers that embrace them; and, although they alternate as the chambers themselves commonly alternate, they produce a pattern similar to that drawn by Mrs. Palmer in her diagrammatic figures. This pattern, therefore, is not caused by lateral chambers surrounding the rays of the equatorial layer, but is due to a typical form of recrystallization within the equatorial chambers. Photographs of thin-sections of these stellate forms are unsatisfactory, as the effects due to recrystallization give the strongest impression. Therefore, I have made a number of camera lucida drawings which are just as accurate as photographs.

The embryonal apparatus and the form of the equatorial chambers in *Asterorbis* are the same as in *Lepidorbitoides*, and, as was suggested by Vaughan and Cole (26), I propose to place these stellate forms with ribs on the test as a subgenus under *Lepidorbitoides*. As a link between these forms and *Lepidorbitoides* s.s. we find in Cuba lenticular forms with a smooth or reticulate surface, described by Palmer as *?Asterorbis cubensis* and *?Asterorbis havanensis*. For these forms that have an equatorial layer with distinct rays but outwardly resemble the true *Lepidorbitoides* forms, I propose the subgenus *Cryptasterorbis*. Type species of the subgenus, *?Asterorbis cubensis*. The generic definition of *Lepidorbitoides* must be enlarged to comprise forms with (1) test stellate or lenticular, and (2) pillars present or absent. The subgenus *Lepidorbitoides* is characterized by a regular, nonstellate equatorial layer.

Cryptasterorbis has a stellate equatorial layer but the test is smooth, lenticular,

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FIG. 4 A, B, I, J—*Lepidorbitoides* (*Cryptasterorbis*) *cubensis* (Palmer). A, Horizontal section showing embryonal apparatus, ×36. B, Horizontal section of same specimen as shown in Plate 61, figure 3, made by drawing mirror. Only the chamber-walls are indicated, ×30. I, Horizontal section of equatorial chambers between the rays with black streaks due to recrystallization, ×45. J, Horizontal section of embryonal apparatus, ×45. (p. 536)

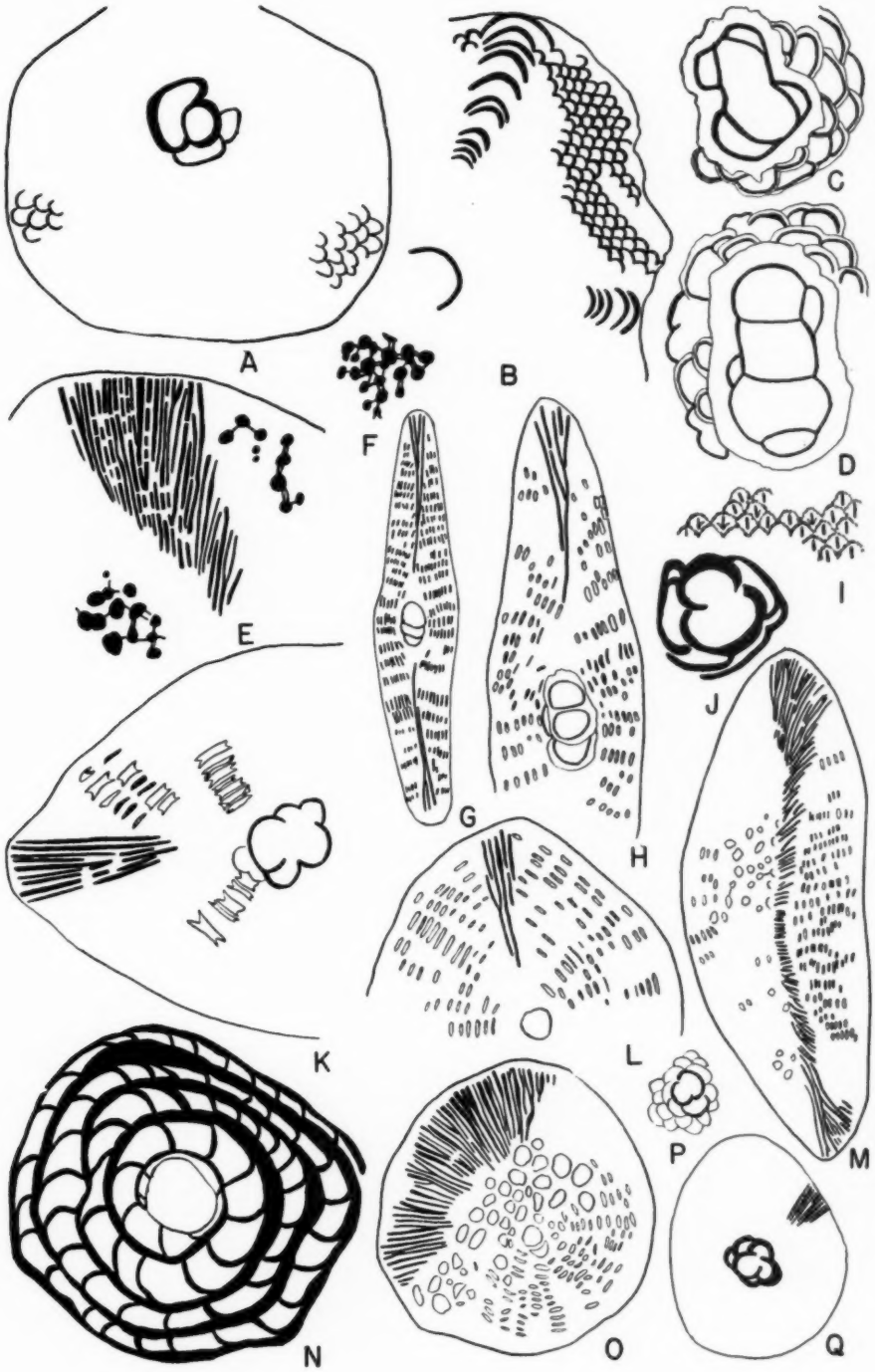
C, D—*Torreina torrei* Palmer. C, Horizontal section of many-chambered embryonal apparatus, ×45. D, Horizontal section of many-chambered embryonal apparatus, ×45. (p. 542)

E–H, M—*Pseudorbitoides trechmanni*H .'Douvillé. E, Oblique section showing equatorial layer and several lateral chambers with stolon passages, ×30. Black, cavities; white, limestone walls. F, Tangential section showing lateral chambers and stolon passages, ×21. G, Slightly oblique vertical section of macrospheric individual, ×15. H, Slightly oblique section of macrospheric individual, ×30. M, Oblique section showing equatorial layer, ×15. (p. 544)

K, L, O, Q—*Pseudorbitoides israelski* Vaughan and Cole. K, Slightly oblique section, showing clearly part of the median layer, ×45. L, Vertical section showing radial equatorial chambers and arrangement of lateral chambers, ×30. O, Oblique section, showing tendency to radial arrangement of lateral chambers, ×30. Q, Horizontal section showing embryonal apparatus, ×18. (p. 544)

N—*Camerina macgillavryi* Rutten, n. sp. Horizontal section of macrospheric specimen, ×9. (p. 530)

P—*Lepidorbitoides* (*Lepidorbitoides*) *planasi* Rutten, n. sp. Horizontal section of embryonal apparatus, ×54. (p. 336)


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q

without elevated rays indicating the arms of the median layer. *Asterorbis* has a stellate test with raised ribs and rays in the equatorial layer.

LEPIDORBITOIDES (CRYPTASTERORBIS) CUBENSIS (Palmer)

Plate 60, figure 5; Plate 61, figures 3, 8, 9; Text figures 4A, B, I, J

?Asterorbis cubensis PALMER, *1934*, Soc. Cubana de Hist. Nat., Mem., vol. 8, no. 4, p. 249, pl. 13, figs. 6, 9, 10; pl. 14, fig. 9.
?Asterorbis havanensis PALMER, *1934*, Soc. Cubana de Hist. Nat., Mem., vol. 8, no. 4, pp. 251, 252, text figs. 13, 14; pl. 13, fig. 11.

Test smooth or reticulate, lenticular, rather thick, in better preserved specimens with four or five very short arms (<0.02 mm.) that are, however, mostly broken. In the equatorial layer there are four or five arms, as in *Asterocyclina*, formed by larger equatorial chambers placed in the same radial row. In the fields between the arms the chambers are smaller, and there are more of them on one radius. This is effected by the interposition toward the margin of the test of more concentric rows of equatorial chambers that pinch out toward the arms. The obscuring effects of recrystallization have been described. In most drawings only the chamber-walls are drawn, and the secondary lines omitted. Palmer separates the larger forms with five arms from the smaller ones with four arms. In my material the diameters vary gradually and I have large specimens with four arms and smaller ones with five arms, so there is no reason to consider them specifically different. Moreover, Palmer (fig. 14, p. 252) shows a specimen of *A. havanensis* measuring about 4 mm., which is the average size of *A. cubensis*.

Measurements of *Lepidorbitoides (Cryptasterorbis) cubensis*

Diameter	1.2 mm. to 5.0 mm.
Thickness	1.8 mm. at a diameter of about 3 mm.
Diameter, first embryonic chamber	0.14 mm. to 0.19 mm.
Diameter second chamber	0.25×0.20 mm. to 0.30×0.16 mm.
Height of equatorial chambers	0.02 mm. to 0.04 mm.
Height of equatorial chambers measured in one of the arms	0.02 mm. to 0.17 mm.

Upper Cretaceous, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14009–14015; 14017–14019; 14215–14220.

Subgenus LEPIDORBITOIDES Silvestri, 1909

LEPIDORBITOIDES (LEPIDORBITOIDES) MINIMA H. Douvillé

Lepidorbitoides minima H. DOUVILLÉ, *1927*, C. R. Soc. Geol. France, Fevrier 21, p. 34.
Orbitocyclina minima VAUGHAN, *1929*, Jour. Paleontology, vol. 3, no. 2, pp. 174, 175, pl. 22, figs. 3–6.

Small, lenticular forms, in some cases slightly asymmetrical. The embryonic apparatus is somewhat larger than indicated in Vaughan's figures, the equatorial chambers are rather small, and their form is typically ogival.

Measurements of *Lepidorbitoides (Lepidorbitoides) minima*

Diameter	1.6 mm. to 4.0 mm.
Thickness	1.1 mm. to 1.5 mm.
Diameter first embryonic chamber	0.09 mm. to 0.15 mm.
Diameters second chamber	0.15×0.07 mm. to 0.24×0.12 mm.
Equatorial chambers horizontally	0.03×0.03 mm. to 0.07×0.05 mm.
Height of equatorial chambers	0.02 mm. to 0.06 mm.

Upper Cretaceous, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 13997–14002, 14016.

LEPIDORBITOIDES (LEPIDORBITOIDES) PLANASI Rutten, n. sp.

Plate 60, figures 6, 7; Text figure 4P

Here are included very small forms in which the state of preservation of the flat, lenticular tests is too poor to permit determination of external features. The small embryonic apparatus in the equatorial layer is typical of the genus. It contains a small subspherical primary chamber, a larger reniform second chamber, and several other chambers, gradually diminishing in size, imperfectly

coiled about these two. Equatorial chambers are small and low. In horizontal section their form is mostly truncate, the sides of chambers in the same row not reaching one another. The lateral chambers are low and not arranged in regular tiers. There are about ten layers of lateral chambers in the thickest part of the test. No pillars apparent.

Measurements of *Lepidorbitoides (Lepidorbitoides) planasi*

Diameter	1.2 mm. to 1.5 mm.
Thickness	0.6 mm.
Diameter first embryonic chamber	0.05 mm. to 0.06 mm.
Diameters second chamber	0.09×0.05 mm. to 0.10×0.04 mm.
Equatorial chambers horizontally	0.03 mm.×0.04 mm.
Height of equatorial chambers	0.03 mm. to 0.04 mm.

In form and size of the embryonal apparatus this species resembles *L.* (*L.*) *nortoni* (Vaughan) (20). It is, however, much smaller, has lower lateral chambers and lacks the pillars. *L.* (*L.*) *minima* Douvillé, moreover, has a larger embryonal apparatus. The species is named in honor of Ing. M. Planas of Havana.

Type locality, upper Eocene, Locality L 485, 3 km. southeast of La Esperanza, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D 14003–14008.

Subgenus Asterorbis Vaughan and Cole, 1932

Lepidorbitoides (Asterorbis) aguayoi Palmer

?Asterorbis aguayoi Palmer, *1934*, Soc. Cubana de Hist. Nat., Mem., vol. 8, no. 4, p. 246, text figs. 6–8; pl. 13, fig. 7.

This species, together with other Cretaceous orbitoids, is common in sample H 153, which is a hard yellow limestone. In thin sections made it is difficult to distinguish this species from *Asterorbis rooki*. The first species is thicker, but in slightly oblique sections this difference becomes less defined. One specimen has a diameter of 5 mm. and a thickness of 2.2 mm. The lateral chambers are not arranged strictly in tiers. About 30 lateral chambers occur above each other in the thickest part of the test.

Lepidorbitoides (Asterorbis) rooki Vaughan and Cole

Asterorbis rooki Vaughan and Cole, *1932*, Nat. Acad. Sci., Proc., vol. 18, no. 10, pp. 611–613, pl 1.

This species is thinner than *L. aguayoi*, but still lenticular and not to be confused with *?asterorbismacei* Palmer. The diameter varies rather strongly. One specimen has a diameter of 2.2 mm. to a thickness of 0.9 mm. The layer of equatorial chambers between the rays does not exceed 0.025 mm., but in the arms it attains a height of 0.13 mm.

Genus Lepidocyclina Gümbel, 1868

In determining the Lepidocyclines I secured much help from the *Key to the American Genus of Lepidocyclina*, by Dr. I. M. van der Vlerk and Miss M. van de Geyn, which the latter kindly sent me in manuscript. Because of the resemblance of different species of the subgenera *Lepidocyclina* and *Nephrolepidina*, I have determined only macrospheric specimens.

Subgenus Lepidocyclina Gümbel, 1868

Lepidocyclina (Lepidocyclina) r.-douvillei Lisson

Lepidocyclina r.-douvillei Lisson, *1921*, Arch. Assoc. Peruana p. el Prog. Ciencia, Tome 1, fasc. 1, pp. 52–55, pls. 3–5.

Rather thin, lenticular, smooth, small isolepidine forms without pillars. Equatorial chambers diamond-shaped, arranged on intersecting curves. Diameter, 2.4 mm. to 4.5 mm.; thickness, 0.8 mm. to 1.8 mm.; embryonal apparatus, 0.45 ×0.39 mm. to 0.84×0.63 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14021–14023.

Lepidocyclina (Lepidocyclina) georgiana Cushman

Lepidocyclina georgiana Cushman, *1920*, U. S. Geol. Survey, Prof. Paper 125-D, pp. 60, 61, pl. 16, fig. 1; pl. 17, figs. 1–3; pl. 18, figs. 1, 2.
Isolepidina georgiana H. Douvillé, *1924*, Soc. Géol. France, Mém. 2, (n. sér.), p. 39, text fig. 22.

Large, flat discoidal forms, in some cases with a low umbo. Surface papillate, many small pillars. Equatorial chambers rhomboid or ogival, arranged on intersecting curves.

Measurements of *Lepidocyclina (Lepidocyclina) georgiana*

Diameter	7 mm. to 9.3 mm.
Thickness	0.6 mm. to 1.3 mm.
Embryonal apparatus	0.48 mm. ×0.39 mm. to 0.75 mm. ×0.45 mm.

In his text Cushman describes the equatorial chambers as hexagonal, but his Plate 18, figure 1, shows them to be rhomboidal and arranged on intersecting curves. In my material there are two species of large flat isolepidine forms representing this specimen and *L. mortoni*. The latter is distinguished by hexagonal or spatulate equatorial chambers that are arranged on concentric circles.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14024–14030.

Lepidocyclina (Lepidocyclina) meinzeri Vaughan

Plate 62, figure 4

Lepidocyclina (Lepidocyclina) meinzeri Vaughan, *1933*, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 11, 12, pl. 3, figs. 1, 2; pl. 4, figs. 1, 2*c*, 3–5.

Large selliform, rather thin, isolepidine forms with a papillate surface. In order to secure a good view of the equatorial plane, I ground this species and *L. semmesi* on small glass tubes with different diameters, varying with the amount of curvature of the specimens ground. For specimens very strongly curved I employed a glass rod. Of course, it is impossible to make thin sections in this way, but by careful illumination so that the shadows do not become too deep, and with closed diaphragm to get enough depth, good photographs may be obtained. The equatorial chambers are ogival or rhomboidal and arranged on intersecting curves. Diameter, 4.4 mm. to 9 mm.; embryonal apparatus, 0.59 ×0.48 mm. to 0.84 ×0.66 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14031–14034.

Lepidocyclina (Lepidocyclina) mortoni Cushman

Lepidocyclina mortoni Cushman, *1920*, U. S. Geol. Survey, Prof. Paper 125-D, pp. 70, 71, pl. 27, figs. 1–4; pl. 28, figs. 1, 2.

Flat discoidal forms with a low umbo and a papillate surface. In some specimens there are larger pustules on the umbonal center. The equatorial chambers are hexagonal or spatulate, arranged on concentric circles. Lateral chambers low, only a few layers even in the thickest part of the test. Diameter, 4.4 mm. to 7.5 mm.; thickness, 0.8 mm. to 1.1 mm.; embryonal apparatus, 0.45 ×0.20 mm. to 0.89 ×0.85 mm.

There are two isolepidine forms of this type, *L. mortoni* Cushman and *L.* (*L.*) *supera* (Conrad) ((27), See 6, p. 40, figs. 23–26, pl. 1, figs. 9, 10). These are rather large, thin, papillate and with chambers arranged on concentric circles. I presumed my specimens to be *L. mortoni* as *L. supera* is an Oligocene species, but I an not sure whether the two species are

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Explanation of Plate 61

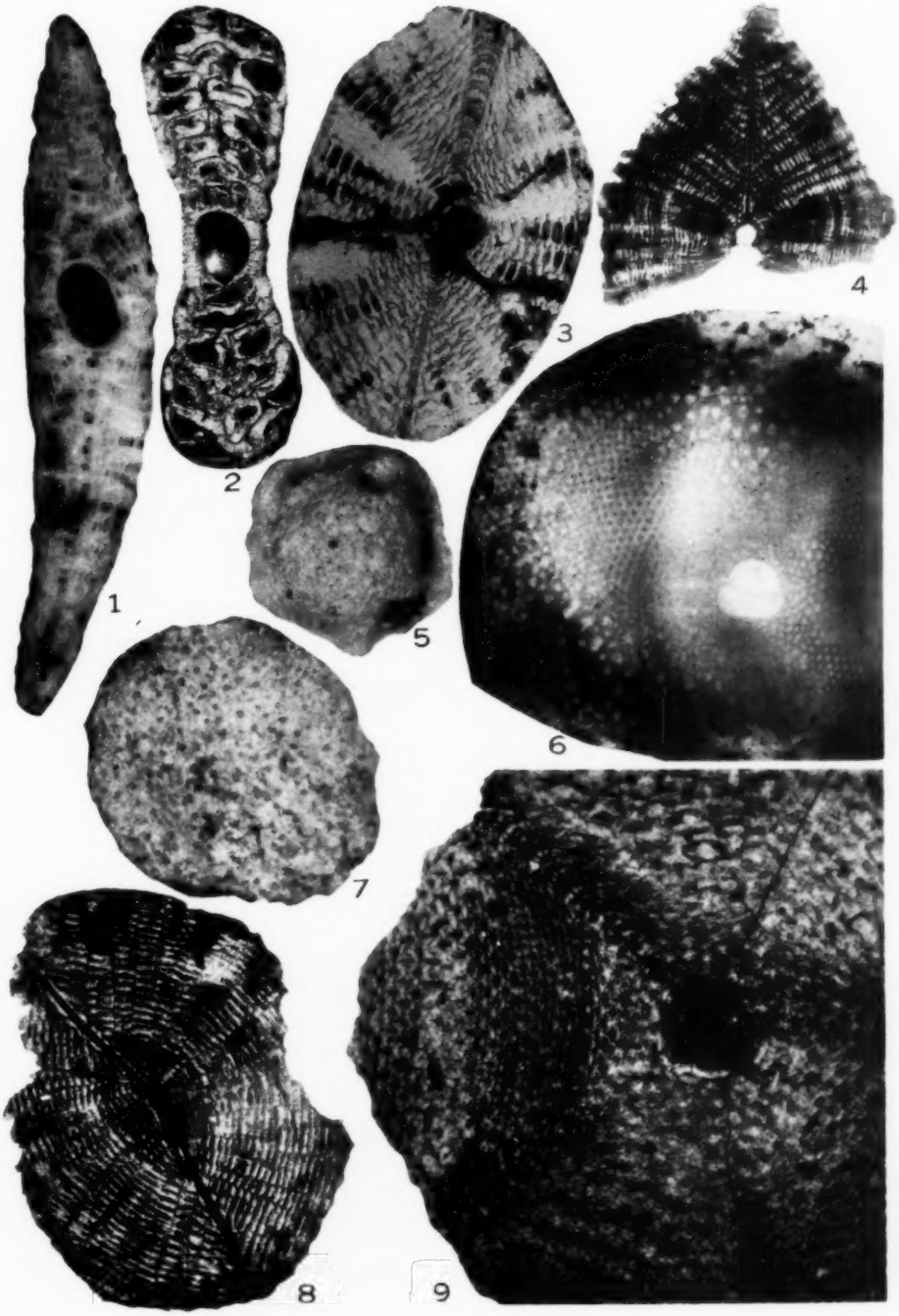
Figs. 1, 7—*Lepidocyclina (Nephrolepidina) piedrasensis* Vaughan. 1, Vertical section, ×11.8. 7, External view, ×9. (p. 539)

2—*Omphalocyclus* sp. Vertical section, ×34.

3, 8, 9—*Lepidorbitoides (Cryptasterorbis) cubensis* (Palmer). 3, Vertical section; at the left side the section passes one of the arms, ×39. 8, Vertical section, ×40.7. 9, Horizontal section, ×40.7. (p. 536)

4, 5—*Discocyclina (Asterocyclina) vermunti* Rutten, n. sp. 4, Vertical section of broken specimen, showing pillars, ×27. 5, External view showing smooth surface and short arms, ×9. (p. 542)

6—*Lepidocyclina (Nephrolepidina) semmesi* Vaughan and Cole. Horizontal concave section showing the equatorial chambers hexagonal and arranged on concentric circles, ×11. (p. 540)



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really distinct. In that case, my specimens, of course, should be called *L. supera* also.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14035–14044.

LEPIDOCYCLINA (LEPIDOCYCLINA) PUSTULOSA H. Douvillé

Isolepidina pustulosa H. DOUVILLÉ, *1917*, C. R. Acad. Sci. Paris, tome 164, p. 844, text figs. 1, 2, 4; *1924*, Soc. Géol. France, Mém. 2, (n. sér.), pp. 41, 42, text figs. 27–32, pl. 1, figs. 2, 3.

Smaller forms lenticular, sometimes with a definite umbo. Surface strongly papillate. Equatorial chambers rhomboid or ogival and arranged on intersecting curves. Diameter, 2.9 mm. to 5.1 mm.; thickness, 0.9 mm. to 1.8 mm.; embryonal apparatus, 0.22 mm. ×0.15 mm. to 0.56 mm. ×0.44 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14045–14053.

Subgenus NEPHROLEPIDINA H. Douvillé, 1911

LEPIDOCYCLINA (NEPHROLEPIDINA) MARGINATA (Michelotti)

Lepidocyclina marginata LEMOINE and R. DOUVILLÉ, *1904*, Soc. Géol. France, Paleont. Mém. 32, pp. 16, 17, pl. 1, fig. 7, pl. 2, figs. 7, 9, 11, 20, pl. 3, figs. 3, 8, 9, 13.

Forms with a conspicuous umbo which in some specimens becomes very high and steep and with a collar of varying extent. Umbo mostly with large pustules. The pillars are heavy and common. The equatorial chambers hexagonal to ogival, arranged on concentric circles. The lateral chambers sometimes form regular tiers, but sometimes they alternate. Diameter, 5.2 mm. to 7.8 mm.; thickness, 2.4 mm. to 3.1 mm.; embryonal apparatus, 0.60 mm. ×0.42 mm. to 1.02 mm. ×0.84 mm.

Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14055–14071.

LEPIDOCYCLINA (NEPHROLEPIDINA) FRAGILIS Cushman

Lepidocyclina fragilis CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 125-D, pp. 63, 64, pl. 22, figs. 1, 2.

Lepidocyclina (Nephrolepidina) fragilis VAUGHAN, *1933*, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 27, 28, pl. 14, figs. 1–4.

Large, thin, reticulate, without pillars. Equatorial chambers ogival to hexagonal; arranged on concentric circles. Only one specimen found. Diameter, 10 mm.; thickness, 0.9 mm.; embryonal apparatus, 0.75 ×0.74 mm.

Oligocene, Santa Clara province, Cuba. Hypotype, Min.-Geol. Inst., Univ. Utrecht, D 14054.

LEPIDOCYCLINA (NEPHROLEPIDINA) PIEDRASENSIS Vaughan

Plate 61, figures 1, 7; Plate 62, figures 8, 9

Lepidocyclina (Nephrolepidina) piedrasensis VAUGHAN, *1933*, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 34, 35, pl. 27, fig. 4.

The nephrolepidine forms from Santa Clara which I place provisorily in this species are rather variable. The thinner specimens are identical with Vaughan's description, and as the variation toward the thicker forms is gradual there is no reason to propose a new name for the thicker forms. If later examination of more material from the type locality of *L. piedrasensis* should prove that that species and my Cuban forms are specifically different, I propose for the Cuban forms the name *Lepidocyclina (Nephrolepidina) petri*. The tests vary from flat discoidal, sometimes a little curved, to flat lenticular. The surface is papillate. Equatorial chambers short-hexagonal to ogival, arranged on concentric circles. Lateral chambers low and irregular. Pillars small, varying in number. Diameter, 4.9 mm. to 10 mm.; thickness, 1.6 mm. to 2.4 mm.; embryonal apparatus, 0.65 mm. ×0.50 mm. to 1.65 mm. ×0.66 mm.

Upper Eocene and Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14076–14093.

LEPIDOCYCLINA (NEPHROLEPIDINA) TOURNOUERI Lemoine and R. Douvillé

Lepidocyclina tournoueri LEMOINE and R. DOUVILLÉ, *1904*, Soc. Géol. France, Paleont. Mém. 32, p. 19, pl. 1, fig. 5; pl. 2, figs. 2, 14; pl. 3, fig. 1.

Nephrolepidina tournoueri H. DOUVILLÉ, *1924*, Soc. Géol. France, Mém. 2, (n. sér.), pp. 47, 48.

Lepidocyclina (*Nephrolepidina*) *tournoueri* VAUGHAN, *1933*, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 25, 26, pl. 13, figs. 1, 2.

Small lenticular forms with rather heavy pillars. Surface papillate, without the pustules of *L. morgani*. Equatorial chambers spatulate to hexagonal, arranged on concentric circles. Lateral chambers rather high, arranged in definite tiers. Diameter, 4.2 mm. to 5.4 mm.; thickness 1.4 mm. to 1.8 mm.; embryonal apparatus, 0.81 mm. ×0.74 mm. to 1.02 mm. ×1 mm.

Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14094–14098.

LEPIDOCYCLINA (NEPHROLEPIDINA) SEMMESI Vaughan and Cole

Plate 61, figure 6

Lepidocyclina (*Nephrolepidina*) *semmesi* VAUGHAN and COLE, *1933*, in Vaughan, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 29, 30, pl. 15, figs. 3–5, pl. 30, figs. 1; pl. 31, figs. 1, 1*a*; pl. 32, figs. 2, 3.

Large, selliform, rather thin forms. Surface papillate. Equatorial chambers regular hexagonal to ogival, arranged on concentric circles. Vaughan and Cole in their text state that the equatorial chambers are diamond-shaped. They have, however, only one bad section on which the equatorial plane is sectioned obliquely, and nothing definite can be said regarding the form of the chambers. By grinding on a glass tube, the equatorial plane can be studied in full and the shape of the chambers better ascertained. Diameter, 3.9 mm. to 8.3 mm.; thickness, 1 mm. to 1.5 mm.; embryonal apparatus, 0.60 mm. ×0.52 mm. to 1.15 mm. ×1.10 mm.

Upper Eocene and Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14099–14109.

Subgenus EULEPIDINA H. Douvillé, 1911

LEPIDOCYCLINA (EULEPIDINA) FAVOSA Cushman

Lepidocylina favosa CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 125-D, p. 66, pl. 15, fig. 5*b*.

Lepidocyclina (*Eulepidina*) *favosa* VAUGHAN, *1933*, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 37–41, pl. 17, figs. 1–3; pl. 18, figs. 1–4; pl. 19, figs. 1–4; pl. 20, figs. 1–3; pl. 21, figs. 1, 3; pl. 29, fig. 4.

This form is readily recognized by the very thick chamber walls, giving a coarsely reticulate surface. The tests vary rather strongly in shape, agreeing perfectly with the descriptions of Vaughan. On the collar the reticulation is always less coarse than on the thicker part of the test. Vaughan, in repeating the description of Cushman, mentions the presence of pillars. I could find none in my specimens but the thick chamber walls in vertical sections often give the impression of pillars. Vaughan (Pl. 17,

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EXPLANATION OF PLATE 62

FIG. 1—*Discocyclina* (*Asterocyclina*) *kugleri* Gravell. Horizontal section, ×36.4. (p. 542)

2—*Pseudorbitoides trechmanni* H. Douvillé. Vertical section, slightly oblique, ×17.7. (p. 544)

3—*Torreina torrei* Palmer. Horizontal section through a young and a full grown specimen, ×13. (p. 542)

4—*Lepidocyclina* (*Lepidocyclina*) *meinzeri* Vaughan. Horizontal, concave section showing diamond-shaped equatorial chambers arranged on intersecting curves, ×6.9. (p. 538)

5—*Pseudorbitoides israelskii* Vaughan and Cole. Slightly oblique section to illustrate state of preservation; showing long radial equatorial chambers, ×28. (p. 544)

6—*Discocyclina* (*Asterocyclina*) sp. External view showing thick umbo and flange with raised ribs, ×11. (p. 542)

7—*Discocyclina* (*Asterocyclina*) *vermunti* Rutten, n. sp. Horizontal section of specimen with six arms, ×26. (p. 542)

8, 9—*Lepidocyclina* (*Nephrolepidina*) *piedrasensis* Vaughan. 8, Vertical section, ×7.6. 9, Horizontal section showing the equatorial chambers short-hexagonal arranged on concentric circles, ×8.4. (p. 539)

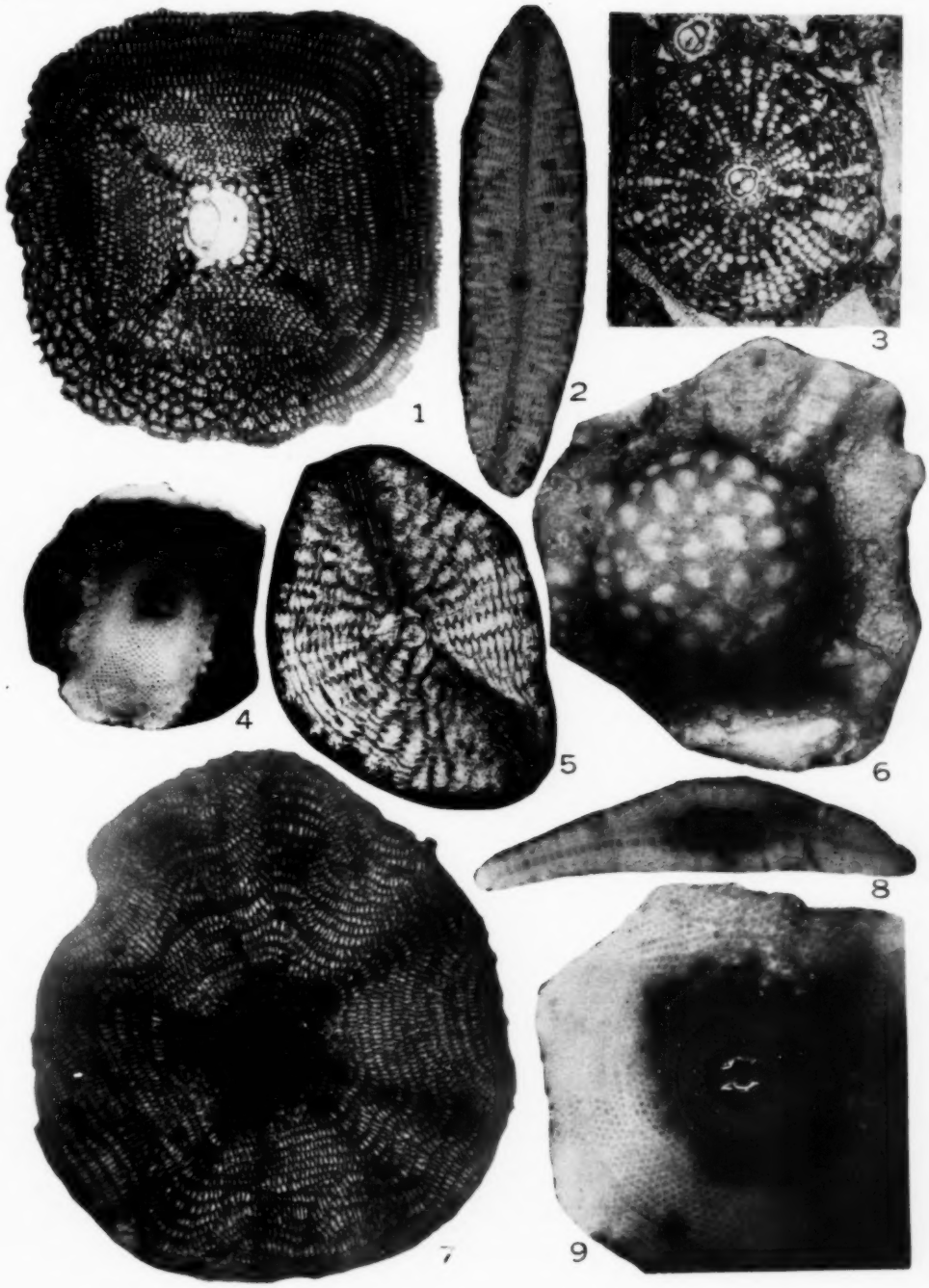

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fig. 3) shows very thick chamber walls and no trace of pillars, and probably they are always absent in this species.

Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14110–14139.

Genus HELICOLEPIDINA Tobler, 1922

HELICOLEPIDINA SPIRALIS (Tobler)

Lepidocyclina (Helicolepidina) spiralis TOBLER, *1922*, Eclogae geol. Helv., vol. 17, no. 3, pp. 380–384.

Helicolepidina spiralis BARKER, *1934*, Jour. Paleontology, vol. 8, no. 3, pp. 345, 346, text figs. 1*a*, 1*c*, pl. 47, figs. 1–4.

Large, microspheric forms; lenticular with a small flange; pillars conspicuous. The spiral reaches the margin in about one and one-half whorl. Diameter, 4.8 mm. to 6 mm.; thickness, 1.8 mm. to 2.7 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14140–14143; 14210.

Genus DISCOCYCLINA Gümbel, 1868

Subgenus DISCOCYCLINA Gümbel, 1868

DISCOCYCLINA (DISCOCYCLINA) BLUMENTHALI Gorter and van der Vlerk

Discocyclina (Discocyclina) blumenthali GORTER and VAN DER VLERK, *1932*, Leidsche Geol. Med., Deel 4, afl. 2, p. 111, pl. 16, figs. 2–4.

Rather large, lenticular, papillate forms with an "eulepidine" embryon. Radial diameter of equatorial chambers about 80μ halfway between embryon and margin. Tangential diameter two to three times smaller. Diameter, 6 mm. to 6.3 mm.; thickness, 2.1 mm. to 2.4 mm.; embryonal apparatus, 0.52×0.52 mm. to 0.59×0.59 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14144, 14145.

DISCOCYCLINA (DISCOCYCLINA) CLOPTONI Vaughan

Discocyclina cloptoni VAUGHAN, *1929*, U. S. Nat. Mus., Proc., no. 2800, pp. 14, 15, pl. 5, figs. 1–6.

This species is identified in thin sections only. Large and very flat, occasionally with a low umbo. Small pillars irregularly distributed; lateral chambers very low, irregular, not in definite tiers, and up to eight layers above each other. Equatorial chambers nearly square, annuli about 80μ apart. Diameter, 6.9 mm. to 9 mm.; thickness, 0.8 mm. in a specimen 6.9 mm. in diameter.

Upper Eocene, Santa Clara province, Cuba.

DISCOCYCLINA (DISCOCYCLINA) CUBENSIS (Cushman)

Orthophragmina cubensis CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 125-D, pp. 40, 41, pl. 7, figs. 1, 2.

Thick, lenticular forms, occasionally with a small flange. Surface papillate, pillars very heavy. In the equatorial plane in the center near the embryonal apparatus is sometimes seen a pattern with indication of rays as in *Asterocyclina*. The rays, however, are mostly very indistinct, and never reach beyond one-third the distance of the embryon to the margin. The radial diameter of the equatorial chambers is two or three times larger than the tangential and measures about 70μ halfway between embryon and margin. Embryonal apparatus small, of "nephrolepidine" type. Lateral chambers very regular; arranged in definite tiers, from 20 to 35 layers above each other in the thickest part of the test. Diameter, 2.8 mm. to 4.8 mm.; thickness, 1.5 mm. to 2.6 mm.; embryonal apparatus, 0.22 ×0.19 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14146–14154.

DISCOCYCLINA (DISCOCYCLINA) PERKINSI Vaughan

Discocyclina perkinsi VAUGHAN, *1928*, Jour. Paleontology, vol. 3, no. 4, p. 285, pl. 46, figs. 4, 5.

Large, flat forms, without umbo; surface papillate; numerous very small pillars. Equatorial chambers nearly square, small. In many sections it is difficult to see the different annuli because of the small diameter of the equatorial chambers, which vary from 20μ to 30μ. Diameter up to 13.2 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotype, Min.-Geol. Inst., Univ. Utrecht, D 14155.

Subgenus ASTEROCYCLINA Gümbel, 1868

DISCOCYCLINA (ASTEROCYCLINA) KUGLERI Gravell

Plate 62, figure 1

Discocyclina (Asterocyclina) kugleri GRAVELL, *1933*, Smithsonian Misc. Coll., vol. 89, no. 11, pp. 23, 24, pl. 3, figs. 1–5.

Small, lenticular form with four rays. Arms mostly broken. Surface papillate or reticulate, no pillars. Equatorial chambers in the central part of the test nearly square, about 25μ in diameter, at the ends of the rays with a radial diameter of 70μ, and two or three times smaller tangentially. Embryonal apparatus "nephrolepidine." Diameter, 1.9 mm. to 3.0 mm.; thickness, 0.8 mm. to 1.5 mm.; embryonal apparatus, 0.22 mm. $\times$0.21 mm.

Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D 14157–14159.

DISCOCYCLINA (ASTEROCYCLINA) VERMUNTI Rutten, n. sp.

Plate 61, figures 4, 5; Plate 62, figure 7

Lenticular form with short arms that are mostly broken, five to seven rays; surface more or less papillate; several heavy pillars; annuli sometimes irregular, tending to obliterate the ray-like *Asterocyclina* pattern. Radial diameter of equatorial chambers two to three times larger than tangential, varying from 60μ to 100μ. Lateral chambers arranged in definite tiers, up to 30 layers above each other in the thickest part of the test. Diameter, 2.9 mm. to 4.5 mm.; thickness, 1.6 mm. to 2.3 mm.; embryonal apparatus, 0.24 mm. $\times$0.20 mm. to 0.44 mm. $\times$0.40 mm.

This species closely resembles *Discocyclina kugleri*, except for the presence of heavy pillars. The partial obliteration of the ray-like pattern by the irregular annuli marks a variation toward *Discocyclina* ss., and in this subgenus we found the variation toward *Asterocyclina* in *D. cubensis*. The limits of variation in *D. cubensis* are close to the more irregular specimens of *D. vermunti* and it is difficult to draw the boundary. This species is named in honor of Mr. L. W. J. Vermunt, Utrecht.

Type locality, upper Eocene, Loc. H 374, near the cemetery of Jicotea, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D 14160–14168.

DISCOCYCLINA (ASTEROCYCLINA) sp.

Plate 62, figure 6

I have one specimen of a very typical *Asterocyclina* that seems to be a new form. A thick almost globular umbo is surrounded by a thin broad collar with four strong raised ribs, corresponding with four rays in the equatorial layer. Umbo and ribs bear heavy pustules, the collar is reticulate. Radial diameter of the equatorial chambers is about two to three times the tangential. Diameter, 5.2 mm.; thickness, 2.1 mm.; diameter of the umbo, 2.6 mm.

Upper Eocene, Santa Clara Province, Cuba. Min.-Geol. Inst., Univ. Utrecht, D 14169.

Genus TORREINA Palmer, 1934

TORREINA TORREI Palmer

Plate 62, figure 3; Text figures 4C, D

Torreina torrei PALMER, *1934*, Soc. Cubana de Hist. Nat., Mem., vol. 8, no. 4, pp. 237, 238, pl. 12, figs. 1, 4.

This species occurs only in one locality, but is extremely common there. Specimens agree very well with Palmer's description. The number of initial chambers inside the thick common wall sometimes goes up to seven, as is illustrated in the figures. Diameter varies strongly.

Upper Cretaceous, Santa Clara province, Cuba. Hypotypes, specimens in sections Min.-Geol. Inst., Univ. Utrecht, D. 14421–14427.

Genus OMPHALOCYCLUS Bronn, 1852

OMPHALOCYCLUS sp.

Plate 61, figure 2

Small specimens of *Omphalocyclus* are common at one locality. They do not

reach 3 mm. in diameter and thus are much smaller than specimens from Maastricht, Holland.

Upper Cretaceous, Santa Clara province, Cuba.

Genus PSEUDORBITOIDES H. Douvillé, 1922

Since previous authors have expressed doubt as to the internal structure of this genus, a full discussion of my material seems warranted. South of Camajuani we found abundant material of *P. trechmanni* and *P. israelskii*. However, with the exception of four weathered-out specimens of the first-named species, all specimens are contained in massive limestone and can be studied in thin sections only. Owing to the extreme abundance of these forms each slide contained a number of specimens, and numerous specimens could be studied. Recrystallization is rather strong and makes photographing almost impossible, so drawings with a camera lucida were made.

The genus is characterized by the doubling of the equatorial layer (5) and by the radiating lines over the median plane (19). According to Vaughan, there is a layer of more or less radially arranged equatorial chambers. Towards the periphery this layer doubles or trebles and over this layer fine radiating lines should be disposed. The nature of these lines could not be ascertained.

In making horizontal sections I did not find any equatorial chambers; only the radiating lines that varied in thickness from 10μ to 30μ. At the periphery there are several layers of these lines. The lines consist of a dark-grayish material with walls of white limestone. The lateral chambers, and also the stolons between these, are filled with the same material that forms the lines, from which I inferred that these are long, channel-like chambers. In following these chambers in horizontal section from the periphery to the center we see how several "channels" bundle together to form one single channel as the space available becomes less. At many places there are breaks in the "channels,"—small transverse dams of white calcite,—and I was unable to ascertain whether or not these breaks are primary or due to the poor state of preservation.

In vertical sections we see an equatorial layer composed of small chambers (19, pl. 21, fig. 6), whereas in horizontal sections equatorial chambers do not appear. I surmised, therefore, that the "chambers" in vertical section are cross-sections through the "channels." As the section is not absolutely radial, and of course the channels are never absolutely straight, a vertical section will cut quite a number of these channels. They are cut rather obliquely and thus appear larger than they really are. The apparent doubling and trebling of the layer of equatorial chambers is caused by the doubling of the median layer of channel-like chambers that take the place of the ordinary equatorial chambers in the other genera of orbitoids. Proof of the absence of ordinary equatorial chambers is furnished by oblique sections. If there were both equatorial chambers and "channels," the chambers in oblique sections would appear bounded on either side by the "channels." This is not the case, for we never see other than the channel-like chambers already described. Toward the lateral parts of the test they are replaced by the irregular lateral chambers. These chambers often are more or less radially disposed in tangential sections near the median plane and here they sometimes have a certain likeness to equatorial chambers of the common type in orbitoids.

To sum up, I find that the test of *Pseudorbitoides* is built up by three groups of layers of chambers. The median layer consists of long, channel-like, radial chambers, appearing as radial lines, and not thicker than 30μ. Toward the periphery this layer doubles and trebles. On either side of the median layer are lateral chambers, rather irregular in form. In vertical sections they

usually appear in tiers; in tangential sections near the median plane they have a tendency to become radially arranged. Communication between the lateral chambers is by means of stoloniferous apertures. Megalospheric and microspheric forms have been observed. The megalospheric embryon is formed by a rather irregular cluster of larger chambers.

In view of the typical equatorial chambers, that are not found in any of the other genera of the Orbitoididae, I propose that the genus *Pseudorbitoides* be designated as the type genus of a new subfamily, the Pseudorbitoidinae. A removal of the genus from the family of the Orbitoididae is not necessary owing to the resemblance of internal structure (consisting of three layers of chambers, embryonic apparatus, forms of lateral chambers and apertures) to the other genera of this family.

PSEUDORBITOIDES ISRAELSKII
Vaughan and Cole

Plate 62, figure 5; Text figures 4 K, L, O, Q

Pseudorbitoides israelskii VAUGHAN and COLE, *1932*, Nat. Acad. Sci., Proc., vol. 18, no. 10, pp. 614–616, pl. 2.

Small, thick, lenticular forms, sometimes nearly globular. Lateral chambers in tiers up to 15 layers above each other. Some short pillars that begin only a short distance from the margin of the test. Diameter, 0.84 mm. to 2.3 mm.; thickness, 0.55 mm. to 1.4 mm.; diameter of first embryonic chamber, 0.11 mm. to 0.23 mm.; distance from the embryon to the point where the equatorial layer doubles, 0.2 mm. to 0.4 mm.

Upper Cretaceous, Santa Clara province, Cuba. Hypotypes, specimens in sections, Min.-Geol. Inst., Univ. Utrecht, D. 14407–14416, 14422, 14427.

PSEUDORBITOIDES TRECHMANNI
H. Douvillé

Plate 62, figure 2; Text figures 4E–H, M

Pseudorbitoides trechmanni H. DOUVILLÉ, *1923*, Soc. Géol. France, Bull., sér. 4, vol. 23, p. 369, text figs. 1, 2.—VAUGHAN, *1929*, Jour. Paleontology, vol. 3, no. 2, pp. 168, 169, pl. 21, figs. 4–6.

Flat discoidal forms with a very low umbo. The lateral chambers are low and arranged in tiers up to 15 layers above each other. In some specimens several short, thick pillars may be observed; in many specimens they are lacking. Several megalospheric individuals were observed in vertical sections. The embryonal apparatus consists of three or more subequal larger chambers, just as in vertical sections of *P. israelskii*. Diameter, 2.8 mm. to 4.8 mm.; thickness, 0.7 mm. to 0.9 mm.

Upper Cretaceous, Santa Clara province, Cuba. Hypotypes, specimens in sections, Min.-Geol. Inst., Univ. Utrecht, D. 14411–14413, 14417–14427.

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PALEONTOLOGICAL NOTES

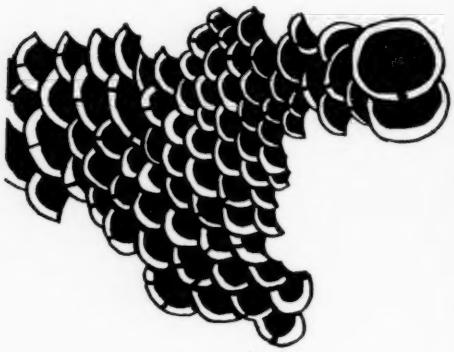
A NOTE ON *ACTINOSIPHON VICHAYALENSIS* (RUTTEN)

M. G. RUTTEN
Utrecht, Holland

In 1928, L. Rutten (2), my father, described under the name *Lepidocyclina* (*?Isolepidina*) *vichayalensis* a new form of orbitoid foraminifera from the Eocene Pariñas sandstone of Peru. There has been considerable controversy as to the systematic place of this species. Todd and Barker in 1932 (3) referred it to the subgenus *Polylepidina*, whereas Barker in 1934 (1) named it *Helicolepidina vichayalensis*.

In order to settle, if possible, the question of generic assignments, my father has permitted me to make a restudy of the type material consisting of a number of beautiful slides in the collection of the Geologisch Mineralogisch Instituut of Utrecht, Holland (D. 10498–10507; 10592–10596). There are both median and tangential sections and in most specimens the chambers are infiltrated by brown iron-bearing matter. This facilitates the study of finer elements of the test, such as the apertures.

The form of the test and the general appearance of the lateral and equatorial chambers are well known from the previous publications and it is not necessary to repeat them here. The equatorial chambers communicate with the lateral chambers by cribriform perforations in the roofs and floors. Communication between the equatorial chambers is by means of stoloniferous apertures. These are to be found at all places, where one chamber wall reaches another. The



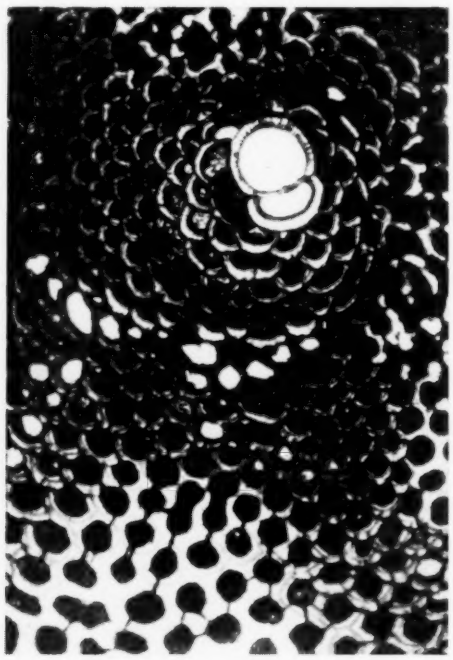


FIG. 1—*Actinosiphon vichayalensis*. Horizontal section drawn with camera lucida. Several medianly placed stolons are seen. The first embryonic chamber communicates by a large passage with the second (×50).

FIG. 2—*Actinosiphon vichayalensis*. Horizontal section. Several medianly placed stolons are seen and a marked spiral arrangement of equatorial chambers is shown (×51).

chambers are ogival, and their side walls are formed by the outer walls of chambers in an inner circle. The chambers have truncate inner ends, as these side walls do not meet. In many cases, moreover, we find stolons in the transverse walls at the truncate inner ends of the chambers. Chambers of one circle communicate in this way directly with radially placed chambers in the following circle. Also, the equatorial chambers tend to form radial rows. These two features are characteristic of the genus *Actinosiphon* Vaughan (4), and are, to my knowledge, not found in any other genus of the Orbitoididae. In accordance with the generic definition given by Vaughan, we find a large subspherical first embryonic chamber, succeeded by a second smaller one. Nothing definitely can be stated about the following chambers, which in *Actinosiphon semmesi*, the genotype, lie in a circle around the larger first and second chambers. This may be due to the irregular build of the species under discussion, where we find in the equatorial plane a more or less conspicuous spiral. Although we do not find entire accordance with the description of the genus, the similarities, such as the medianly placed stolons, the arrangement of the equatorial chambers in more or less regular radial rows, and characters of the first two embryonic chambers, indicate convincingly that the species belongs to the genus *Actinosiphon*. The spiral arrangement of the chambers suggests a relationship with *Helicolepidina*. If this be true, the stolons of *Helicolepidina* should be placed in the same way as in *Actinosiphon*. In the material which is present in this Institute I could not ascertain this. I found only the regular *Lepidocyclina*-type of stolons, but there are no specimens filled with colored matter, while Canada balsam preparations failed.

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REVIEW

Mills, Frederick Wm., An Index to the genera and species of the Diatomaceae and their synonyms, 1816–1932, pts. 1–21, Wheldon and Wesley, London, 1933–1935.

The appearance in February, 1935, of part 21 brings to a close the most momentous index of the diatoms, living and fossil, ever attempted, and the work will take its place with the really great compilations of biologic literature. The last part contains a portrait of the author and a supplement of 39 pages; this additional matter consists of certain authors' classifications of particular genera, a supplemental list of titles to literature (some as late as 1934), and additions and corrections to the main body of the text.

Printing conditions in England were such that the author was obliged to bring the work out by the "multitype" (mimeograph) process, but even so considerable financial loss was suffered. The selection of paper was very good and the impressions are as legible as typewriter printing could be desired. A complete collation of the work follows:

Part	*Date Issued*	*Pages*	*Contents*
1	May, 1933	1– 74	Bibliography. *Acanthoceras—Achnanthes vernalis*
2	July, 1933	75– 148	*Achnanthidium crenulatum—Amphora areolata* var. *curta*
3	Aug., 1933	74a,149– 222	*Achnanthidium—A. coarctatum* var. *elineata* (p. 74a); *Amphora areolata* var. *elegans—Attheya zachariasi* (pp. 149–222).
4	Sept., 1933	223– 296	*Aulacocystis—Biddulphia parallela*
5	Oct., 1933	279– 372	*Biddulphia parvula—Chaetoceros atlanticus* var. *exigua*
6	Nov., 1933	373– 448	*Chaetoceros atlanticus* var. *neapolitana—Conferva comoides*
7	Dec., 1933	449– 526	*Conferva comoides—Cyclotella kützingiana*
8	Jan., 1934	527– 606	*Cyclotella kützingiana* var. *caspa—Diploneis adonis* var. *gibbosa*
9	Feb., 1934	607– 684	*Diploneis adonis* var. *oamaruensis—Eunotia heptodon*
10	Mar., 1934	685– 762	*Eunotia Herkiniensis—Gaillionella italica*
11	Apr., 1934	763– 840	*Gaillionella Juergnesi—Hemiaulus angustus*
12	May, 1934	841– 920	*Hemiaulus antarcticus—Melosira arenaria*
13	June, 1934	921–1000	*Melosira arenaria* var. *definita—Navicula californica*
14	July, 1934	1001–1080	*Navicula caliginosa—Navicula leonis*
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16	Sept., 1934	1162–1240	*Navicula suavis—Nitzschia vermiculata*
17	Oct., 1934	1241–1320	*Nitzschia verrucosa—Plagiotropis van neurickii*
18	Nov., 1934	1321–1400	*Plagiotropis vitrea—Rhizosolenia antennata*
19	Dec., 1934	1401–1480	*Rhizosolenia antarctica—Stephanodiscus berolinensis*
20	Jan., 1935	1481–1570	*Stephanodiscus biharensis—Synedra nana*
21	Feb., 1935	1571–1726	*Synedra neopolitana—Zygoceros weissflogii* (p. 1687); supplement, pp. 1688–1726; portrait of the author.

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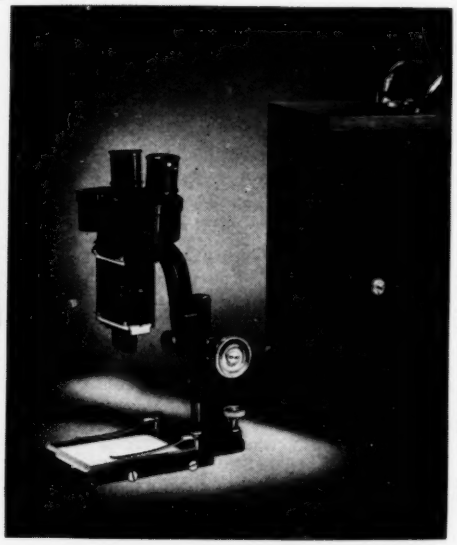

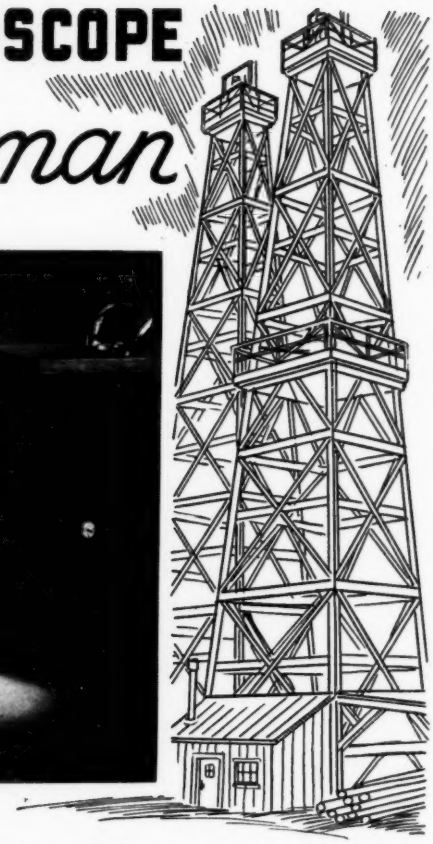

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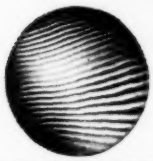

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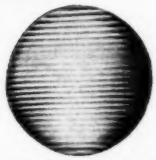

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